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MISSOURI

BOTANICAL GARDEN.

SIXTH ANNUAL REPORT.

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ST. LOUIS, MO.:
PUBLISHED BY THE BOARD OF TRUSTEES.
1895.

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---

* *Ex officio.*

[1] Elected President of the Academy of Science January 7th, 1895, in place of Henry S. Pritchett, who had met with the Board for three years prior to that date.

MISSOURI BOTANICAL GARDEN
LIBRARY
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No.

PREFACE.

Under direction of the Board of Trustees, the sixth annual report of the Missouri Botanical Garden is offered to the public. This volume differs from those which preceded it in the omission of the section consisting of "anniversary publications," comprising the annual flower sermon and the proceedings at the two annual banquets instituted by Mr. Shaw, the Director's report containing all that it is considered necessary to state concerning these.

The fifth report was issued April 27th, 1894. Reprints of papers from the present volume were issued in advance of its publication as follows:—

Smith, Sagittaria and Lophotocarpus, May 24th, 1894; Trelease, Leitneria Floridana, May 30th, 1894.

The reports of the Garden are sent regularly to scientific institutions and journals in exchange for publications or specimens desirable for the library and herbarium of the Garden, and, so far as is possible, reprints of the botanical articles which they contain are sent to botanists to whom these papers are directly useful.

Regular agents for the sale of Garden publications are Dr. A. E. Foote, of Philadelphia, W. Wesley & Son, of London, and R. Friedländer & Sohn, of Berlin.

WILLIAM TRELEASE.

St. Louis, March 1, 1895.

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YUCCA GLAUCA, NUTT.

REPORTS FOR THE YEAR 1894.

REPORT OF THE OFFICERS OF THE BOARD.

SUBMITTED TO THE TRUSTEES JANUARY 9TH, 1895.

To the Board of Trustees of the Missouri Botanical Garden:

The financial results for the past year have been very satisfactory considering the depressed condition of trade. Although some of the properties of the Board have been vacant all or a portion of the year, the receipts from rentals have exceeded those of the previous year over $1,000.00, and at this date, with fewer vacancies, the income will undoubtedly be in excess of that of the past year several thousand dollars.

The properties of the Board have been kept in good repair and nearly all are occupied by desirable tenants at fair rentals.

No extensive improvements have been made at the Garden, but the addition of a plant-house costing about $2,700.00 and several granitoid ponds for the growing of the Victoria Regia and other lilies have added greatly to the beauty and attractiveness of the Garden during the summer months, as well as offering additional attractions in the way of blooming plants throughout the winter.

After carrying out Mr. Shaw's bequests for annual banquets, flower sermon, and premiums for the flower show, caring for the Garden and paying all expenses of

caring for the properties of the Board, we are enabled to carry forward a gain of $19,824.18 for the year.

Additions have also been made to the library, herbarium, and furniture for the library building, and the following sums have been credited to the stock account, which now aggregates $1,480,886.18: —

Library (purchases and donations)	$4,361 71
Herbarium (purchases and donations)	908 70
Missouri Botanical Garden permanent improvements	3,887 53
	$9,157 94

For a full and detailed account of the receipts and expenditures you are referred to the following statement: —

RECEIPTS.

Rents	$93,252 87	
Stock Account sales	32 10	
Garden pasturage and sales	684 30	
Interest and cash discount on taxes	1,359 70	
Garden hand-book sales	71 00	
Publications sales	36 50	
Loss by fire to buildings	119 50	$95,555 97
Cash balance January 1st, 1894		15,649 75
Total		$111,205 72

EXPENDITURES.

Garden Account —		
Labor, including garden pupils	$14,096 62	
Fuel	1,582 87	
Stable and implements	604 44	
Repairs and supplies	1,849 37	
Scholarship, care of lodge and supplies	767 44	
Plants and seeds	284 08	
Herbarium	860 51	
Library, books, subscriptions, etc.	2,614 90	
Garden office, salaries, supplies, etc.	5,362 54	
Research	475 50	$28,498 27
Garden Improvements Account —		
Greenhouse, buildings, etc.	5,135 25	5,135 25
Publication Account —		
Annual volume	1,849 87	1,849 87
Property Expenses —		
Commission for collecting rents	1,070 45	
Taxes, State, school, city and sprinkling	20,980 86	
Streets, pavements and sewers	353 99	
Insurance	3,977 43	
Repairs	5,041 62	31,424 35
Office Account —		
Salaries	2,821 33	
Rent of office	815 00	
Printing, postage, telephone and furnishing	1,372 18	5,008 51
Sundry Accounts —		
Legal expenses	72 65	
Repairs to buildings damaged by fire	119 50	192 15
Bequests —		
Premiums to flower show*	577 00	
Flower sermon	200 00	
Trustees' banquet	905 10	
Gardeners' banquet	336 59	
Washington University (School of Botany)	1,673 60	3,692 29
Invested		15,000 00
Cash on hand December 31st, 1894		20,405 03
Total		$111,205 72

* Of this sum $100 (toward cost of medal) was properly chargeable to the year 1893, in which only $400 appears as having been paid for premiums — see Fifth Report, p. 9.

The books of the Board have been closed after showing the operations for the year ending December 31, 1894, and the receipts have been disposed of as follows: —

Rent account		$93,252 87
Interest		1,359 70
Garden hand-book		71 00
		$94,683 57

CONTRA.

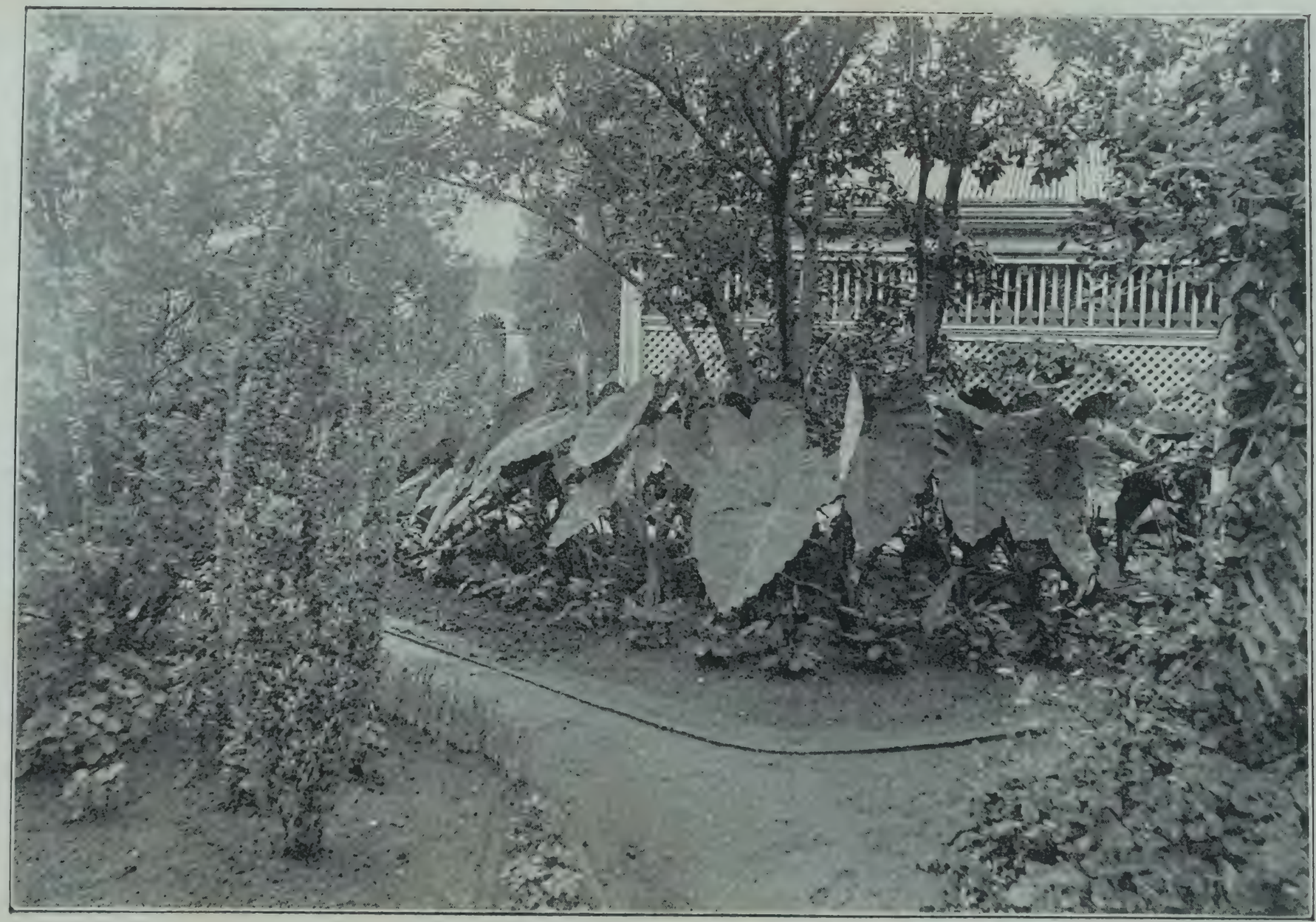
Garden expense	$28,069 98	
Office expense	5,008 51	
Commission	1,070 45	
Repairs	5,041 62	
Insurance	3,977 43	
Taxes	20,980 86	
Street pavements and sewers	353 99	
Legal expenses	72 65	
Washington University (School of Botany)	1,673 60	
Annual flower sermon	200 00	
Annual Trustees' banquet	905 10	
Annual Gardeners' banquet	336 59	
Annual flower show	577 00	
Publications	1,813 37	
Garden improvements	4,778 24	
Surplus for 1894	19,824 18	
	$94,683 57	$94,683 57
Surplus Dec. 31, 1893		$40,649 75
Surplus for 1894		19,824 18
Total surplus December 31, 1894		$60,473 93

Respectfully submitted,

R. J. LACKLAND, *President.*

Attest,

A. D. CUNNINGHAM, *Secretary.*



COLOCASIA ANTIQUORUM.

SIXTH ANNUAL REPORT OF THE DIRECTOR.

SUBMITTED TO THE TRUSTEES JAN. 9, 1895.

To the Board of Trustees of the Missouri Botanical Garden:

The following report on the Missouri Botanical Garden and the Henry Shaw School of Botany is respectfully submitted, in compliance with the rules of the Board:—

THE BOTANICAL GARDEN.

During the past year the number of visitors to the Garden is reported by the gate-keeper to have been somewhat greater than in 1893, and the Head Gardener, who has been familiar with the Garden for many years, estimates that about one-third more persons now visit the grounds than was the case a few years ago, — an increase partly due to the increased facilities which now exist for reaching the Garden, and, perhaps, in part to the attractions which have been added during the last few years. On the open Sunday afternoon in June, 20,159 visitors were noted, and on the open Sunday in September, which was showery, about 15,500. As in previous years, the visitors on these Sundays were orderly and apparently well disposed. During the year, visitors have purchased 256 copies of the little handbook of the Garden offered for sale at the gate.

In the second paragraph of the first clause of his will,* the founder of the Garden directs that the Garden shall be kept open during such hours, and under such regulations as the Trustees shall prescribe, "every day except Sundays, for the use of the public at large." In the thirty-fourth paragraph of the fourth clause of the same instrument,† he adds: "In the first clause, and second

* First Garden Report, p. 32.

† l. c. p. 51.

paragraph of this my last will and testament, I devise and express my wish that the garden shall be kept open, under necessary regulations, Sundays and holidays excepted, every day of the week. Now as this Trust is made for the use of the citizens of St. Louis as well as the public in general; it is my wish that for the convenience of said citizens and public, that the Garden shall be open to visitors two Sundays in each year, viz, the first Sundays in June, and the first Sunday in September, from Two P M to sunset." During the later years of Mr. Shaw's life, it was his custom to close the Garden on Sunday, but for the convenience of strangers in the city unable to visit the Garden on other days, he issued a limited number of Sunday cards, each admitting from one to four persons, and also allowed the occasional visits of a larger number. Such permits have been given in a few instances since the death of Mr. Shaw, but it has always been questionable whether they were strictly possible under the power conferred on the Trustees by Mr. Shaw's will, which by implication directs that the public as a whole and also individuals shall be refused admittance on Sundays and holidays; and, however much they may regret the necessity for so doing, the Board of Trustees have decided that under the instructions contained in the will they have no option except to close the Garden on Sundays and holidays (except the Sunday afternoons mentioned above), to individual visitors as well as to the public as a whole.

The general decorative features of the grounds were maintained through 1894 on substantially the same lines as in the preceding year, though somewhat more color was introduced, especially near the main entrance. A collection of economic fiber plants, in the northwestern part of the Garden proper, was made a special feature this year. Although for a time during the extreme drought of the summer, the lawns suffered greatly, the Garden has been kept in a fairly attractive condition through the season. The average number of laborers (including seven garden pupils) was 37, and

the pay-roll for the year aggregates $14,096.62, of which a considerable sum was expended for necessary repairs to greenhouses and other structures.

Some years ago an effort was made to cultivate undershrubs and other small plants at suitable points in the arboretum, by the establishment there of a wild garden.* Owing to the severity of the seasons and the extent to which the closely set trees of the arboretum have taken possession of the soil, this feature has not added to the attractiveness of the Garden as largely as was hoped, but there is seldom a time during the open season when the wild garden and bog do not contain a considerable number of interesting plants in bloom, and it is hoped that their success may be increased in the future. The droughts which have prevailed during the past five summers, and the impervious subsoil, have continued to weaken the older trees, especially conifers, so that, as was stated a year ago, it is probable that few of the latter will survive many years longer; and a very severe frost, coming when the earlier species were beginning their vegetation last spring, killed outright many trees, such as the weeping willows, while it paved the way for further harm during the exceptionally hot and dry summer which followed. Where they are needed, other trees are being planted to make good the losses from these causes, but it is difficult to successfully grow a new tree on the spot from which an old one has been removed, and a more general clearing and tasty replanting will become necessary within a few years.

The most generally attractive features added to the grounds this year are a series of new granitoid lily ponds, one of which, situated south of the Linnean house, was planned for the growth of the *Victoria Regia*, or Amazon water lily. The decorative effect of these ponds was very considerable, and they were the source of favorable comment by the press of the city and by visitors. A much

* Third Report, p. 13.

needed plant house, 21 × 97 feet, was erected in the summer, just south of the *Victoria* pond, and is adding greatly to the attractiveness of the Garden through the winter. Numerous minor improvements have been reported to the Board in detail, month by month.

The fruticetum, reported on at various times in the past,* has been further improved this year by the removal of all of the old and worthless apple trees and grape vines and the laying of 1,630 feet of drain tile, and is to be largely replanted in the spring to carefully selected varieties of fruit. The appearance of this inclosure has been greatly enhanced by the replacement of the dilapidated picket fence separating it from the arboretum, by a neat open wire fence. It is hoped that these horticultural improvements may be extended by the erection in the near future of a much needed vegetable forcing house, with a grapery compartment.

During the year, some 950 packets of seeds and 1,000 plants have been received by way of donation or exchange, and 850 packets of seeds and a few dozen plants distributed. The largest of the accessions consisted in 952 plants, many of them of great value, received from South Park, of Chicago. A limited number, aside from bulbs and other transient plants, have also been added to the Garden by purchase. Some 26,900 bedding plants were propagated at the Garden for out-of-door decoration, — an increase of some 6,000 as compared with the preceding year. On the approach of winter, some 1,100 of these were taken from the ground and potted, and distributed to charitable institutions and poor homes in the city, through the kindness of the Bethel Association, to whose officers I wish to express my indebtedness.

While much remains to be desired, the labeling of the plants of the Garden is being greatly improved each year, and I hope that it will not be long before every plant will

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* Garden Reports, ii. 18–20, 30; iii. 12.

A TROPICAL BED.

be correctly and legibly named. The enamel (granite ware) tree labels which were at first tried have not proved satisfactory, for several reasons, and trees of sufficient size are now receiving zinc alloy labels cast with raised letters, and affixed by two pins in a vertical line, so as to admit of the expansion of the tree during growth. For the smaller plants, celluloid labels, lettered with a special ink, have been employed very largely, and present a neat appearance when wired to the plants or fastened before them; but it has thus far proved to be impossible to letter them so as to insure permanency, and experiments are being tried in the hope of securing labels combining durability and attractiveness with reasonable cost.

The herbarium has been increased by the incorporation of 9,307 sheets of specimens, of which 3,567 sheets were purchased, 126 belonged to the Bernhardi herbarium, and 5,614 were received by donation or exchange. 208 mounted sheets of duplicates from the Engelmann herbarium, and 12 mounted duplicates from the general herbarium, besides about 1,000 unmounted duplicates, have been distributed to correspondents by way of exchange. As now constituted, the herbarium contains the following collections:—

The Engelmann herbarium (all groups), about.....		97,800	specimens.
The general herbarium of higher plants:			
The Bernhardi herbarium.....	61,120		
Other specimens.....	54,687		
		115,807	"
The collection of Thallophytes:—			
The Bernhardi herbarium.....	126		
Other specimens.....	17,794		
		17,920	"
Making a total of about.....		231,527	"

During the year $1,720.11 was spent for purchases and binding for the library, the additions to which consist of 373 books and 166 pamphlets purchased, and 379 books, valued at $733.95, and 999 pamphlets, valued at $207.65,

donated or received by way of exchange. Sixty large volumes of Dr. Engelmann's manuscript notes and sketches are appraised at $600.00. An indexer has been kept steadily employed during the greater part of the year on the card index of plant illustrations in the library; and the card index of Experiment Station literature published by the United States Department of Agriculture, and a set of index cards referring to recently published plant names, have been added by purchase. It is estimated that the card indexes at the library now number about 110,000 cards appraised at $1,100.00, exclusive of the authors' catalogue of books and pamphlets. Exclusive of the Sturtevant prelinnean collection of about 460 volumes, which has not yet been appraised and added to the capital stock account, the library now contains:—

Books..... 7,631
Pamphlets.. 9,822

Together. 17,453 works, and 110,000 index cards, valued at $29,630.23.

I have been assisted in office and similar work by Mr. J. C. Whitten, Horticultural Assistant, Jared G. Smith, Botanical Assistant, Miss Grace E. Johnson, Artist, Eva M. Reed, Indexer, and C. E. Hutchings, Amanuensis. In October, Mr. Whitten left the Garden to accept the professorship of horticulture at the Missouri State University, and his place has been filled by the appointment of Mr. H. C. Irish, of the South Dakota Agricultural College. In addition to the necessary routine work, time has been found for a certain amount of research work by Mr. Smith and myself, and phenological notes were also made through the year by Mr. Whitten, and by garden pupils under his direction. Several papers embodying the results of such work are now in preparation. The Garden table at the Wood's Holl Marine Biological Laboratory was again used this year by Mr. M. A. Brannon, who informs me that his studies on *Grinnellia* are now so far

completed that they will soon be ready for publication. Through the summer, I utilized a four months' leave of absence by visiting the Azores, where a large collection was made, quite fully representing the flora of these islands, and adding somewhat to what was known of the distribution of species through the groups of islands. This collection is now being worked over by me, and may, perhaps, form the subject for a paper to be published in the seventh Garden Report. Mr. Smith is at present devoting a portion of his time to a study of the Capsicums which have been cultivated and collected during the past three years, and toward which study Dr. E. Lewis Sturtevant contributed his valuable sets of notes, drawings, and specimens in 1892.*

Four annual events have taken place in the manner directed in Henry Shaw's will: namely, the preaching of a sermon on the wisdom and goodness of God as shown in the growth of flowers, fruits, and other products of the vegetable kingdom; the fifth banquet to the Trustees of the Garden and their invited guests; the fifth banquet to the gardeners of the institution and invited florists, nurserymen and market gardeners; and the award of premiums or prizes to a flower show or exhibition.

The flower sermon was preached in Christ Church Cathedral, St. Louis, on the morning of May 13, by Right Reverend T. F. Gailor, Assistant Bishop of Tennessse.

The Trustees' banquet was given at the Mercantile Club of St. Louis, on the night of May 18, and was presided over by Professor H. S. Pritchett, President of the Academy of Science of St. Louis. Covers were laid for about seventy-five persons. Among those present were: —

J. C. Arthur,
Purdue University.
O. D. Ashley,
New York.
Shepard Barclay,
Jefferson City, Mo.
C. C. Hemenway,
Pritchett Institute.

* Fourth Garden Report, p. 15.

F. C. Hicks,
University of Missouri.
R. H. Jesse,
University of Missouri.
T. H. McBride,
University of Iowa.
Conway MacMillan.
University of Minnesota.
Oren Root,
Hamilton College.
E. M. Shepard,
Drury College.
W. von Streeruwitz,
Austin, Tex.
F. E. Nipher,
C. R. Sanger,
E. H. Sears,
M. S. Snow,
of Washington University.
George D. Barnard,
Adolphus Boeckeler,
W. W. Boyd,
J. P. Bryson,
M. Dwight Collier,
F. M. Crunden,
Thomas Dimmock,
Daniel Dillon,
Daniel D. Fisher,
S. W. Fordyce,
D. R. Francis,
Fred. Gabel,
W. C. Glasgow,
C. S. Greeley,
John Green,
Henry C. Haarstick,
James Hagerman,
Edwin Harrison,
Charles M. Hays,
E. A. Hitchcock,
W. L. Huse,
F. L. James,
J. E. Kaime,
Henry King,
Jacob Klein,
W. H. Lee,
J. M. Leete,
Geo. E. Leighton,
R. E. MacMath,
W. C. Marshall,
Albert Merrill,
N. O. Nelson,
Byron Nugent,
Charles Parsons,
Julius Pitzman,
Thomas C. Purdy,
P. G. Robinson,
R. E. Rombauer,
O. U. von Schrader,
W. L. Sheldon,
Wm. Short,
F. L. Soldan,
Charles Speck,
E. O. Stanard,
S. S. Sumner,
Edwards Whitaker,
O. L. Whitelaw,
W. G. Williams,
James Withrow,
of St. Louis.
F. W. Brockman,
W. S. Chaplin,
Geo. S. Drake,
Henry Hitchcock,
D. F. Kaime,
R. J. Lackland,
H. S. Pritchett,
D. S. Tuttle,
Jas. E. Yeatman,
Trustees of the Garden.
A. D. Cunningham,
Secretary Board of Trustees.
Wm. Trelease,
Director of the Garden.

After the dinner, toasts appropriate to the occasion were gracefully proposed by the chairman, and responded to fittingly by President R. H. Jesse, of the University of

Missouri, Professor Oren Root, of Hamilton College, President O. D. Ashley, of the Wabash Railway, and Dr. John Green and the Reverend William Short, of St. Louis.

The gardeners' banquet was given at the Mercantile Club of St. Louis, on the night of November 5, and was presided over by the Director of the Garden. About seventy-five guests were present, among them: —

A. G. Fehr, Belleville, Ill.
E. W. Guy, Belleville, Ill.
A. S. Halstead, Belleville, Ill.
G. E. Meisner, Bushberg, Mo.
A. Nelson, Lebanon, Mo.
E. A. Riehl, Alton, Ill.
Homer Riggle, Columbus, O.
O. C. Simonds, Chicago, Ill.
J. F. Stinson, Fayetteville, Ark.
A. L. Vaughan, Chicago, Ill.
G. A. Washburn, Bloomington, Ill.
J. C. Whitten, Columbia, Mo.

R. W. Ayres,
J. J. Beneke,
H. W. Chandler, Jr.,
N. J. Colman,
C. L. Connon,
Chas. Connon,
J. M. Connon,
J. W. Dunford, Jr.,
Wm. Ellison,
F. J. Fillmore,
R. Frow,
Wm. Hackman,
J. C. Jannopoulo,
J. M. Jordan,
C. A. Juengel,
Wm. Klockenkemper,
John Koenig,
Julius Koenig,
C. A. Kuehn,
Geo. Longman,
Leonard Matthews,
Fred Meister,
E. H. Michel,
F. W. Ostertag,
Henry Ostertag,
Wm. Pape,
Julius Pitzman,
C. C. Sanders,
Carew Sanders,
Wm. Schray,
J. W. Schuette,
R. F. Tesson,
A. Waldbart,
N. J. Wellhouse,
J. F. Windt,
C. W. Wors,
Harry Young,

of St. Louis.

J. W. Branch,
F. W. Brockman,
R. J. Lackland,
D. S. Tuttle,

of the Board of Trustees.

A. D. Cunningham,

Secretary of the Board.

O. L. Simmons,
C. H. Thompson,

of the School of Botany.

Thomas Doss,
J. W. Dunford,
Philip Giebel,
Jas. Gurney,
C. E. Hutchings,
H. C. Irish,
C. I. Paige,
J. M. Paige,
J. P. Pillsbury,
Chas. Schmidt,
J. G. Smith,
Geo. Stockey,
Wm. Trelease,
Mike Zavadil,

of the Botanical Garden.

In response to toasts proposed by the chairman, short and apt speeches were made by Mr. O. C. Simonds, of Chicago, President of the American Association of Cemetery Superintendents, Professor J. C. Whitten, of the University of Missouri, President F. W. Brockman of the St. Louis School Board, and Messrs. Leonard Matthews, Julius Koenig, and Julius Pitzman, of St. Louis.

The award of flower premiums for 1894 was again intrusted to the Florists' Club of St. Louis, for the benefit of a chrysanthemum show held in the Exposition Building, St. Louis, November 6 to 9. Some of the premiums were not competed for, and were consequently not awarded, and the exhibition judges decided that none of the plants competing for the gold medal founded in 1893 were sufficiently meritorious to justify the award of the medal.

The object of Mr. Shaw in providing for "premiums or prizes to a flower show or exhibition * * * established by amateurs and horticulturists of St. Louis," evidently was to stimulate public interest in floriculture, to improve and increase the variety of plants used in St. Louis, and to stimulate and assist florists in their efforts to create and supply a demand for decorative plants. In approving the suggestions of the Florists' Club for a list of the Shaw premiums each year, an effort has therefore been made so to shape the list as to add to the general attractiveness of the exhibition and at the same time also to familiarize the public with new or easily cultivated plants not usually to be seen in the local florists' windows. It was in the hope of bringing to these St. Louis exhibitions newly introduced plants, as well as to stimulate the importation of such plants, that in 1893 the Board of Trustees of the Garden founded "the Henry Shaw Medal for the introduction of a valuable plant," open to competition in any line of decorative horticulture, but to be awarded only "for a plant of decided merit for cultivation, not previously an article of North American commerce, and introduced to such commerce by the exhibitor during the year in which said award

is made,'' * and it is hoped that importers and originators of new plants of merit will be encouraged to compete for this medal by the precedent established this year by the Florists' Club in refusing an award except in case of very decided merit, in conformity with the wishes of the Trustees.

Mr. Shaw's expressed wish for the instruction of garden pupils has this year borne fruit in the completion of the gardening course by Mr. Homer Riggle, who was given a scholarship in the spring of 1890, and who on the completion of his studies at the Garden, was appointed to a gardener's position at the Ohio State University; and Mr. J. P. Pillsbury, who would have completed the course in March, 1895, has been appointed assistant to the Horticulturist of the Pennsylvania State College, and will probably apply for examination for a certificate in 1895, after completing the work required of garden pupils.

While the number of free scholarships contemplated by Mr. Shaw, and provided for in 1889, is limited to six, so many applications have been received for the admission to the garden classes of paying pupils, that at its meeting of November 16th, 1894, the Board of Trustees authorized the Director "to admit, in addition to those holding garden scholarships, as many suitably prepared garden pupils as can, in his judgment, be adequately taught without material increase in the cost of tuition, each pupil so admitted to be charged $25.00 per year tuition, and to be entitled to the same certificate as a scholarship pupil on completion of the required course and examinations.'' In November, therefore, a sixth announcement was issued, stating that the vacancy caused by the withdrawal of Mr. Pillsbury would be filled in March next, by the appointment of a scholarship pupil, and that applications would be considered from persons desirous of entering the Garden next April as pupils without any of the scholarship grants or payments, and subject to the payment of a tuition fee of twenty-five dollars at the beginning of each class year.

To avoid unnecessary duplication of instruction both at

* Fifth Report, pp. 18, 19.

the Garden and the School of Botany, the course of study for garden pupils has been re-arranged as is shown in the appended table, so that the work of the third and fourth years may be given alternately to two combined classes, the second year's class work only being repeated each year.

COURSE OF STUDY.

YEAR.	TERM.	STUDIES.					PER WEEK.
SECOND.	April to June.	Floriculture. 3 exercises weekly.	Economic Entomology. 1 exercise weekly.		Surveying. 2 exercises weekly.		6
	July to Sept.	Floriculture. 3	Economic Entomology. 2	Book-Keeping. 1			6
	Oct. to Dec.	Floriculture. 1	Economic Entomology. 2		Surveying 1	Elementary Botany. 3	7
	Jan. to Mar.	Floriculture. 1	Twigs of Woody Plants. 1	Orchard Culture. 1	Landscape Gardening 1	Elementary Botany. 3	7
THIRD.	April to June.	Vegetable Gardening 4			Landscape Gardening 1	Elementary Botany. 2	7
	July to Sept.		Economic Mycology. 1	Orchard Culture. 2	Landscape Gardening 1	Botany of Garden Flowers. 2	6
	Oct. to Dec.		Economic Mycology. 3		Botany of Fruits. 2	Vegetable Physiology 1	6
	Jan. to Mar.		Economic Mycology. 3		Botany of Weeds. 1	Vegetable Physiology 2	6
FOURTH.	April to June.	Orchard Culture. 1	Forestry. 1	Book-Keeping. 1	Surveying and Drainage. 3		6
	July to Sept.	Small Fruit Culture. 4		Garden Accounts. 1		Botany of Vegetables 1	6
	Oct. to Dec.	Special Gardening 2	Forestry. 1	Garden Accounts. 1		Botany of Woody Plants. 2	6
	Jan. to Mar.	Special Gardening 2	Forestry. 1		Botany of House Plants. 2	Botany of Ferns. 1	6

OPUNTIAS IN THE CACTUS HOUSE.

The 75 class exercises per week here tabulated (each extending over three months), may be grouped under subjects as follows:—

Gardening:			
Floriculture	8		
Vegetable gardening	4		
Fruit culture	8		
Forestry	3		
Landscape gardening	3		
Selected thesis work	4	30	
Surveying and drainage		6	
Bookkeeping and accounts		4	
Economic entomology		5	
Botany in its relation to gardening:			
General botany	8		
Botany of decorative plants	5		
Botany of hardy woody plants	3		
Botany of fruits	2		
Botany of vegetables	1		
Botany of weeds	1		
Economic mycology	7		
Vegetable physiology	3	30	75

Subjects capable of being taught in the laboratory, the greenhouse, or the field, are so taught, and all of the theoretical instruction is expected to be practically tested in the performance of manual labor, to which the entire first year, and half of each day through the remainder of the course, is devoted. Vacations are granted from July 1 to 15, and December 21 to January 4, inclusive.

THE SCHOOL OF BOTANY.

On the opening of the college year 1894–5, the instructional force of the School of Botany was increased by the appointment of Mr. Orville L. Simmons as instructor in cryptogamic botany, Mr. C. H. Thompson continuing to act as general instructor. In the spring of 1894, a course of Saturday lectures and demonstrations in pollination and plant fertilization was given by me at the Garden to 33 persons, laboratory work was given to 3 teachers, and two

classes, including 45 children, were taught elementary botany at the Garden by Miss A. I. Mulford, through the same term. During the past autumn, Miss Mulford has further conducted two classes, consisting of 23 persons, in the study of ferns and of the fruits and seeds of flowering plants.

The appended list of electives now offered by its undergraduate department is taken from the forthcoming catalogue of Washington University.

1. Elementary Morphology and Organography, with reference to Oecology and Systematic Botany. Lectures and demonstrations by the Professor, as a full study through the first term.
2. Elementary Anatomy and Phanerogamic Botany. Laboratory work under the General Instructor, as a full study through the second term.
3. Synoptical study of the Cryptogams. Laboratory work under the Instructor in Cryptogamic Botany, as a full study through the first term, followed, if desired, by:—
4. A special study of some group of Cryptogams, as a full study through the second term.
5. Methods of Vegetable Histology. Laboratory work under the General Instructor, as a full course through the first term.
6. Histology and Morphology of the Higher Plants. Laboratory work under the General Instructor, as a full study through the second term, accompanied, if desired, by:—
7. A laboratory study of the minute anatomy of the lower Cryptogams, under the Instructor in Cryptogamic Botany, as a full course for the same term.
8. Technical Microscopy of Timbers. Laboratory work under the Professor, as a half course during the first term.

9. Economic Botany. Lectures by the Professor, supplemented by laboratory demonstrations by the Instructors, as a full course for the second term.

10–11. Applied Mycology. Laboratory work under the Instructor in Cryptogamic Botany, as a full course extending through the year.

12–13. Garden Botany. Laboratory study of cultivated plants, at the Botanical Garden, under the Director and his Assistants, for one or two terms.

14. Vegetable Physiology. Laboratory work under the General Instructor, as a full course for the first term.

It is intended that course 1 shall always be followed by course 2, the two being preparatory to other electives. For the present, unless special reason to the contrary exists, courses 1 and 2 only will be given each year, the remaining electives being offered in alternate years as follows: —

First year (as offered for 1894–5), —
First term, courses 1, 3, 12, and 14.
Second term, courses 2, 4, 9, and 13.
Second year (as offered for 1895–6), —
First term, courses 1, 5, 8, and 10.
Second term, courses 2, 6, 7, and 11.

Students who have taken courses 1 and 2, or have had their equivalent elsewhere, are admitted to any of the other elementary electives which can be taken without conflict with other University work; but students who desire to equip themselves as botanists are advised to take the electives as nearly as possible in the order in which they are offered, and on the completion of the elective courses should expect to devote not less than ten hours per week through an entire year to some piece of research work, selected under the advice of the Professor of Botany.

The instrumental, library and herbarium equipment of the School of Botany and the Garden are or can easily be made ample for the proper teaching of these electives. All of the courses capable of being taught in the laboratory are so taught, supplemented by necessary lectures and reading, and the few lecture courses offered are illustrated whenever possible by specimens of plants and their products.

In addition to these undergraduate studies, post-graduate work is planned to suit the needs of candidates for advanced degrees, and one applicant for the Doctor's degree is taking such work through the present year.

Besides the classes already mentioned, two advanced students have been more or less steadily occupied in herbarium work at the Garden through the year, several visiting botanists have made protracted use of the herbarium and library, and the Garden representatives of several difficult genera of plants have passed through the hands of specialists engaged in the revision of these groups; and it is intended that under needful restrictions all of the facilities of the Garden shall always be available for the use of any suitably prepared person engaged in botanical work.

Very respectfully,

WILLIAM TRELEASE,
Director.

January 9, 1895.

SCIENTIFIC PAPERS.

A REVISION OF THE NORTH AMERICAN SPECIES OF SAGITTARIA AND LOPHOTOCARPUS.

BY JARED G. SMITH.

The principal published revisions of the Alismaceae are those of Engelmann,* Buchenau,† and Micheli.‡ The present revision has been based on a study of the material contained in the Engelmann and general herbaria of the Botanical Garden, and in the herbaria of the Shaw School of Botany, Harvard University, the United States Department of Agriculture, Columbia College, the University of Nebraska, Kansas Agricultural College, the University of Minnesota, and in the private herbaria of Mr. Walter Deane, Dr. Charles Mohr, Mr. P. A. Rydberg, and Mr. Henry Eggert. My cordial thanks are also tendered to the many correspondents who have contributed specimens to the Garden Herbarium. I have been especially aided in this work by and am largely indebted to the many and copious manuscript notes and drawings made by Dr. George Engelmann during his life-long study of these genera. Not only

* Dr. George Engelmann, in A. Gray, Man. (1848); Ed. 2 (1856); Ed. 5 (1867). For complete references see The Botanical Works of George Engelmann, Collected for Henry Shaw, 496 (1887).

† Franz Buchenau, Index Criticus Butomacearum, Alismacearum Juncaginacearumque hujusque descriptarum, in Abh. Nat. Ver. Bremen (1868).— Nachtraege zu den kritischen Zusammenstellungen der bis jetzt beschriebenen Butomaceen, Alismaceen und Juncaginaceen, Bremen, (1871).— Beitraege zur Kenntniss der Butomaceen, Alismaceen und Juncaginaceen, in Engler, Bot. Jahrb. **2**: Heft 5 (1882).— In Engler und Prantl, Die Natürlichen Pflanzenfamilien **2**: *1*, 227 (1889).

‡ Marc Micheli, in DC. Monog. Phan. **3**:29 (1881).

did Dr. Engelmann examine the material preserved in all of the principal American herbaria, but in his visits to Europe in 1856–7, and 1883, he studied the types and American collections preserved in the great English and Continental herbaria. These notes and the types in his own very rich herbarium have served as a foundation for the work undertaken.

I have followed Buchenau and Micheli in separating the species of Lophotocarpus from Sagittaria. Lophotocarpus is annual (at least our species), the flowers are perfect or staminate, and the stamens are hypogynous. Sagittaria is perennial, monoecious or dioecious with the fertile flowers never perfect, and the stamens are borne above the receptacle. The separation of Lophotocarpus simplifies the genus Sagittaria very much, reducing somewhat its cosmopolitan character. In their present form the genera more nearly express the genetic relationship.

Sagittaria is a genus consisting of from ten to thirty species, according as the ideas of the various monographers differ. A large part are American, the rest extending over Europe and Northern Asia. Of the twenty-two species which I have recognized in North America, one is only an introduced ballast plant, and one extends into Central and South America.

The American *S. latifolia*, together with the related species of the group *Sagittifoliae*, has been considered as falling within the limits of the widely distributed European and Asiatic *S. sagittifolia*. Micheli, in DC. Monog. Phan. **3**: 66, 69, and, following him, a number of American systematists, have held this opinion. Dr. Engelmann, in A. Gray, Man. Ed. 2 (1856), first pointed out the differences which separate the two species. Buchenau, in Engler, Bot. Jahrb. **2**: 486 (1882), supports this view that they are distinct. In this I have followed Engelmann and Buchenau. The two species occupy different geographical ranges and are isolated one from the other, although both undoubtedly derived from the same stock. The American species are

more closely related to the Asiatic than to the European forms of *sagittifolia*.

Classification according to leaf forms has proved very unsatisfactory. After examining nearly two thousand herbarium specimens, besides much living material, I have found that there is least variation in the form and size of the achenium, form of the anthers, pubescence or lack of pubescence of the filaments, relative length of fertile and sterile pedicels, and within certain limits in the form of the bracts. As in most aquatics, the leaves vary through wide limits in the same species, and characters founded on leaf differences, at least among the *Sagittifoliae*, are of little value. Some reliance, however, may be placed on the relative length of the lobes or divisions of the leaf, excepting always in the immature or phyllodial forms. The phyllodia themselves are too variable to be of much diagnostic value, though some of our more recent American systematists have endeavored to draw specific characters from them. Phyllodia are not always present. In some species they seem to offer wider differences than the leaves. They appear to be formed principally when conditions are unfavorable for the development of aerial leaves, and whether they are considered degraded leaf forms, or reversions to a previously existing type, the characters which they present have little specific value.

Intravaginal squamules as noted by Buchenau in Engler, Bot. Jahrb. **2**: 467 (1882), are present in the Alismaceae and allied orders. They consist of from one to three rows of very delicate scales attached in the axils of the leaves to the dorsal edge of the petiole. They are linear-lanceolate, 2 to 4 mm. long, colorless, from one to three or four cells thick at the base. They may be easily studied on young plants of the common *S. latifolia*, and will probably be found in other species.

Many or possibly all of our North American Sagittarias, in common with the Old World species, form underground autumn tubers. These have been observed in *S. latifolia*,

S. graminea, *S. heterophylla*, *S. longiloba* and *S. papillosa*. Horizontal or oblique rhizomes are present in *S. lancifolia* and *S. graminea cycloptera*. The tubers of *latifolia*, *graminea* and *heterophylla*, are edible. They are used by the Indian tribes of the Northwest, and are called either Wappatoo, or Wabesipinig, the latter meaning Swan-potatoes, because of their furnishing food for the numerous wild-fowl of that region. The tubers are formed in the mud at the depth of 2 to 4 dm. In the spring they throw out a long rhizome which forms at its upper end a corm, and from this corm arise the roots and leaves.

The descriptions given in the following synopsis have been drawn as far as possible from herbarium specimens or the living plants. The exceptions were *Sagittaria lancifolia angustifolia* (Lindl.) Griseb., and *Lophotocarpus Guyanensis* (HBK.)Mich., both from Mexico. These were adapted from Micheli, because of the insufficiency of material in the herbaria examined.

Since contributing a list of the Sagittarias of the Eastern United States to the Mem. Torr. Bot. Club, Vol. **5**: 25 (1894), I have examined fuller material of *S. graminea platyphylla*, and have thought best to raise the variety to specific rank.

The limited bibliography given includes the principal works used in the preparation of this paper. It was believed that its value as a systematic monograph would not be enhanced if the great mass of minor references were printed. I have endeavored to make the synonymy complete as far as original descriptions of American species are concerned. Buchenau and Micheli have given the fuller bibliography, and I will refer any who are interested in the study of these genera to their cited works. If deemed necessary, the more complete bibliography may be published at some future time.

SAGITTARIA L. Sp. Plant, 993 (1753). — Flowers all unisexual, but the staminate frequently with abortive pistils at center; filaments inserted above the receptacle.

ANALYTICAL KEY.

1. Sepals of the pistillate flower reflexed or spreading, not accrescent.

* Fertile pedicels slender, ascending, neither much thickened nor reflexed in fruit.

+– Leaves sagittate; filaments glabrous, not dilated.

++ Basal lobes equaling or shorter than the middle one.

= Beak more than one-fourth the length of the achenium.

Fertile pedicels much shorter than the bracts; leaves ample; beak of the achenium stout, erect. *S. longirostra.*

Fertile pedicels longer than the bracts; leaves with linear lobes; beak of the achenium erect. *S. Engelmanniana.*

Beak of the achenium lateral, horizontal or oblique. *S. latifolia.*

= = Beak of the cuneate obovate achenium very short, erect, retrorse; basal lobes very short.

Petioles short and curving; bracts long, scarious margined; terrestrial, or emergent aquatic. *S. arifolia.*

Petioles long and slender; bracts short; submerged aquatic with flowers at the surface of the water. *S. cuneata.*

++ ++ Basal lobes more than half the length of the leaf.

Basal lobes 2 or 3 times as long as the middle one; stamens less than 24; seed coat punctate. *S. longiloba.*

Basal lobes less than twice as long as the middle one; stamens 30 or more; seed coat not punctate. *S. Greggii.*

+– +– Leaves entire or hastate.

++ Filaments slender, not dilated; leaves pseudo-penninerved.

Filaments glabrous; bracts short, densely papillose; achenium short-obovate. *S. papillosa.*

Filaments glabrous; achenium falcate; fertile pedicels longer than the sterile. *S. ambigua.*

Filaments cobwebby pubescent; achenium falcate. *S. lancifolia.*

++ ++ Filaments dilated, pubescent; veins free to the base of the leaf.

a. Fertile flowers sessile; scape geniculate at the lowest verticil; achenium stoutly beaked. *S. rigida.*

b. Fertile pedicels shorter than the sterile; achenium 3 mm. long, broadly winged, the sides smooth.—In South Carolina. *S. macrocarpa.*

c. Fertile pedicels about as long as the sterile.

Leaves terete and mostly bladeless.—Species of the Atlantic coast. *S. teres.*

Leaves rigid, elliptical-linear, somewhat triquetrous. *S. cristata.*

Leaves neither rigid nor terete. *S. graminea.*

* * Fertile pedicels much thickened, reflexed in fruit.

a. Filaments dilated, pubescent. *S. platyphylla.*

b. Filaments dilated, glabrous.

Stamens 7 or 8.

Scape simple. *S. subulata.*

Scape branching, longer than the linear submerged leaves. *S. filiformis.*

Stamens 12 or 13. *S. demersa.*

c. Filaments slender, glabrous; leaves entire; achenia cuneate quadrate. *S. Sanfordii.*

* * * Fertile pedicels much thickened, ascending; filaments slender, glabrous; scape shorter than the leaves. *S. Mexicana.*

2. Sepals of the pistillate flower erect and accrescent; petals with a brownish purple spot at the base. *S. Montevidensis.*

SYNOPSIS OF THE SPECIES OF SAGITTARIA NORTH OF MEXICO.

A. Sepals of the pistillate flower reflexed after flowering, not enlarging in fruit; petals white.

§ *Sagittifoliae.* Leaves sagittate or rarely when submerged entire, or reduced to bladeless phyllodia; filaments glabrous, not enlarged at the base; sterile pedicels longer than the fertile.

* Achenium obovate cuneate, the beak minute, erect, retrorse; filaments shorter than or equaling the anthers; basal lobes less than half the length of the leaf; bracts slightly connate.

S. ARIFOLIA Nutt. in herb.— *S. sagittifolia minor* Pursh, Flora Amer. Sept. **2**: 395 (1814).* *S. variabilis* var. *hastata* forms *b* and *c* in part, Macoun, Cat. Can. Pl., **4**: 77, 78 (1888).

Terrestrial, or emergent aquatic, weak, ascending, 2 to 4 dm. high; petioles rather stout, usually curving outward; blade of leaf 6 to 12 or 18 cm. long, arrow-shaped, acute, the margin mostly straight or arcuate, basal lobes divergent, acute or acuminate; scape weak, ascending, simple or rarely branched; bracts lanceolate, acute, 8 to 20 mm. long, scarious margined and obscurely veined, often reflexed; 1 to 3 lower verticils pistillate; fertile pedicels ascending, 15 to mostly 25 mm. long, or sometimes almost wanting; fruiting head round, 8 to 15 mm. in diameter; achenium 2 mm. long, tumid winged on both margins, the

* Pursh gives the range as "Pennsylvania to Carolina;" but Dr. Engelmann in his manuscript notes says that Pursh's plant is from the Rocky Mountains and that it "seems to be exactly like" a specimen collected by Nuttall.

sides smooth, or often with a vertical subepidermal resin passage. Phyllodia of two forms, either long, slender, petiole-like, or flattened, linear-lanceolate, 2 to 5 dm. long and 10 to 15 mm. wide.— Along streams or sandy margins of lakes and ponds, in the mountains from British Columbia to California, Nevada and New Mexico, and from western Kansas and Nebraska to Minnesota and Quebec.

Phyllodial or immature specimens are difficult to distinguish from plants of *S. latifolia* form *c* of similar habit. The species perhaps approaches most closely the Northern European and Asiatic *S. sagittifolia*, from which, however, mature specimens are easily separated. The achenia are much smaller, and cunate-obovate instead of nearly orbicular as in the European species. — Plate 1.

Specimens examined from British Columbia (Macoun, Kamloops, 1879, and 1889, *S. variabilis hastata* form *c*, Sicamous, 1889); Washington (Dr. Lyall, 1860; Suksdorf, 1318, Sept. 1893, Klickitat Co.); Oregon (Kellogg and Harford, 952, 1869; Howell, Sauvies Island, 1887; Nuttall); California (Bolander, Sierras, 1870; Vasey, 1875; Mrs. Ames, 1876, Plumas Co.; Mrs. Austin, 1877); Nevada (Stevens, Pac. R. R. Surv.; Torrey, 506, 1865, Lake Washoe; Bailey, 1151, 1867, Truckee Valley; Palmer, 1876); Utah (S. Watson, 1151, 1869, Salt Lake Valley; Jones, 1071, Salt Lake City, 1879); Colorado (Jones, 1878, Denver); New Mexico (Wislizenus, 27 and 225, 1846, the latter with irregularly approximate whorls; Fendler, 837 and 839, 1847; Edwards, 1849, Santa Fé, the "*S. Mexicana*" of Herb. Torrey but not of Engelmann); Northwest Terr. (Parry; Macoun, 1751, 1879, Eagle Hills "*S. variabilis gracilis*", —— Land Hills, "*S. variabilis hastata* form *b*,—— and 1883, Moose Mountain Creek); Manitoba (Bourgeau, 1857, Winnipeg Valley); Idaho (Leiberg, 526, 1891, Lake Pend d'Oreille, "in water 3-12 dm. deep, or in simply wet places," "on sandbars, shallow bays and mouths of rivers, abundant," many forms); Montana (Notestein, 1893, Great Falls); Geyer, Nicollett's Northwest Expedition, 1839; S. Dakota (Williams, 16, 1892, Big Stone Lake and many other localities. Specimens from Big Stone Lake have branched scape with whorls irregularly approximate, lobes of leaf linear, much elongated, and two kinds of phyllodia on the same plant); Nebraska (H. Engelmann, Platte Bottoms, 1852, 1856 and 1858, the latter with bracts 25 to 30 mm. long; Smith and Pound, 235, 1892, Sand Hills; Bates, Sand Hills); Iowa (Hitchcock, 1891); Minnesota (Minneapolis, 1877, "N. H. W.," with broadly ovate leaves, submerged scape, the irregularly approximate fertile verticils each with 3 to 6 flowers; Bailey, 154, 1886, Vermillion Lake; Sandberg, 1179, 1891, Lake Itasca); Michigan (Davis, 1890, Alma; Kofoid, 1890 and 1891, Cheboygan Co., and "sandy margins of Black

Lake)" ; Ontario (Macoun, 1884, Nipigon River, *S. variabilis hastata* form *c*). An immature specimen from Macoun, 1882, Grand Vallée, Gaspé, *S. variabilis hastata* form *c*, probably goes here.

S. ARIFOLIA STRICTA n. var.

Slender, erect, 3 to 4 dm. high; blade of leaf 2 to 5 cm. long; scape simple, erect; bracts ovate, acute, 6 to 8 mm. long; fertile pedicels 8 to 15 mm. long; fruiting head 1 cm. in diameter; achenium smooth or laterally unicostate.— Boggy meadows and slow streams, Falcon Valley, Washington, W. N. Suksdorf, 1319 (674), Aug. 1, 1885.— Plate 1.

S. CUNEATA Sheldon, Bull. Torr. Club, **20**: 283, pl. 159, (1893).

Submerged aquatic, rooting in the sand; leaves long petioled; blade floating, small, 5 to 8 cm. long, with linear lobes; scape simple, slender, terete, 6 to 9 dm. long, bearing verticils of flowers at the surface of the water; bracts ovate-lanceolate, acute, 4 to 6 mm. long; stamens few (?); fruiting head small, about 1 cm. in diameter; achenium 1 mm. long. Phyllodia of two forms, either linear attenuate, petiole-like, reaching nearly to the surface of the water, or lanceolate, 6 to 12 cm. long, 4 to 8 mm. wide, clustered at the base.— In shallow ponds, or margins of lakes, from British Columbia to Minnesota.— Plate 2.

Specimens examined from British Columbia (Dawson, Aug. 1888, Kamloops; Macoun, 1889, Sicamous); North West Territory (Macoun, 1751, 1879, Eagle Hills); Washington (Suksdorf, 2262, 1889, Philles Lake, Spokane Co.); South Dakota (Williams, 15, 1892, Big Stone Lake); Minnesota (Sheldon, 3576, East Battle Lake,—3925½, Blanche Lake,—3926½, Mollie Stark Lake, 1892).

* * Achenium obovate, the beak prominent, ¼ to ½ as long as the ovary; filaments longer than the anthers; basal lobes not more than half the length of the leaf; bracts, at least of the lower verticils, free.

S. LATIFOLIA Willd. Sp. Pl. **4**: 409 (1806). *S. gracilis* Pursh, Fl. Am. Sept. 396 (1814). *S. simplex* Pursh, l. c., described from staminate scape, and leaf of *Rumex*. *S. variabilis* Engelm. in A. Gray, Man. 461

(1848). *S. sagittifolia* of Amer. authors, not Linn. *S. sagittifolia*, var. *variabilis* Micheli in DC. Monog. Phan. **3**: 69 (1881), in part, not *S. longiloba* Engelm. *S. variabilis* var. *angustifolia* Engelm. in A. Gray, Man. Ed. 5, 493 (1867). *S. variabilis* var. *diversifolia*, Engelm. in A. Gray, Man. Ed. 5, 493 (1867). *S. variabilis* var *gracilis* Engelm. in A. Gray, Man. Ed. 5, 493 (1867). *S. hastata* Pursh, l. c. *S. variabilis* var. *hastata* Engelm. in A. Gray, Man. Ed. 5, 493 (1867). *S. variabilis* var. *hastata* form *a*, and in part forms *b* and *c*, Macoun, Cat. Can. Pl. **4**: 77, 78 (1888). *S. obtusa* Willd. Sp. Pl. **4**: 409 (1806). *S. sagittifolia* var. *macrophylla*, and var. *vulgaris* Hooker Fl. Bor. Amer. **2**: 167 (1840). *S. Chinensis* Parish, Zoe, **1**: 122 (1890). *S. Sinensis* Brandegee, Zoe, **4**: 217 (1893), not Sims.

Monoecious, with the lower verticils fertile, or dioecious; scape 1 to 12 dm. high, angled, simple or branched; flowers large, 2 to 4 cm. wide, the petals white; stamens numerous, 25 to 35; fertile pedicels shorter than the sterile; bracts sometimes connate in the upper verticils, acute, acuminate, or obtuse, not scarious; achenium broadly winged on both margins, 2.5 to 3.5 or rarely 4 mm. long, with a lateral horizontal or curving beak $\frac{1}{4}$ to $\frac{1}{3}$ its length, sides usually smooth, or with a costate angle curving downward from the base of the beak, rarely with a subepidermal resin passage on each face.— An extremely variable species, extending from Nova Scotia to British Columbia, south along the Pacific Coast to California, and throughout the region east of the Rocky Mountains to Mexico and Florida. —Plates 3 to 7.

The species is a complex one on account of its wide geographical distribution and varying habitat. After an examination of nearly all the available material, the species seems best divided into forms instead of varieties, of which I recognize five. These merge into one another, so that it is difficult to draw hard and fast lines between them. The

first represents, as far as I am able to determine, the species in its most typical form.

S. latifolia proper.— Monoecious or subdioecious; large, erect, 3 to 6 dm. high; leaves longer than broad, glabrous or rarely pubescent, 15 to 40 cm. long, with lobes from broadly ovate, acute, to linear lanceolate, acute or acuminate; scape erect, simple or branched; bracts glabrous, acute or acuminate, 1 to 5 cm. long; verticils rarely approximate, mostly more than five; fertile pedicels 2 to 4 or sometimes 6 or 8 cm. long; fruiting head 15 to 30 mm. in diameter; achenium about 3 mm. long.— This is the common form from Massachusetts and New York west to Colorado, and south to Florida and Louisiana.

Specimens examined from Prince Edward Island (Macoun, 1888); Ontario (Macoun, 1884; Britton, 1889); Massachusetts (Deane); New York (Torrey; Morong); New Jersey (Dr. Gray, 1833; Bernhardi; Britton, 1889); Pennsylvania (Durand, 1848; Porter); Ohio (Riehl, 1838); S. Carolina (M. A. Curtis); Alabama (Mohr); Indiana (Case, 1878; S. Watson, 1890, Crawfordsville, has a branched scape with 6 lower whorls fertile, fruiting head 20 to 25 mm. in diameter on pedicels 15 to 20 mm long, bracts 3 cm. long, acuminate, achenium crested, 2.5 mm. long, the beak oblique); Illinois (Engelmann and many collectors); Missouri, common; Michigan (Farwell, 729, 1889; Schneck, 1881; Davis, 1890); Minnesota (Sandberg, Red Wing, 1885, 622, 1891; Taylor, 907, 1891, Glenwood); Iowa, common; S. Dakota (Williams, 1892, numerous localities); Eastern Nebraska and Kansas, common; Colorado (Denver, Fritchey, 1886); Louisiana (Dr. Hale, specimens with ovate bracts 1 cm. long); Florida (Dr. Chapman, 1863, with the upper part of the petiole and the under surface of the leaves pubescent, fertile pedicels and acuminate bracts 1 cm. long, bracts and sepals glabrous).

This form includes a part of *communis*, and all of *acuta* and *subdioica* of the Engelmann Herbarium, and a part of Macoun's var. *hastata*, Cat. Can. Pl. *l. c.* The common form in Indiana, Illinois, Iowa and Missouri, has a dorsally crested obliquely beaked akene 2 to 2.5 mm. long, fertile pedicels 12 to 15 mm. long, shorter than the acuminate bracts. This passes into the form with longer (3 to 3.5 mm.) akenes with horizontal beaks. I am unable to separate them except geographically. The dorsally crested

form is confined to the Mississippi Valley. The horizontal beaked form is found throughout the range.

Two specimens in the Engelmann Herbarium have a bract of the lowest whorl foliaceous; that of a specimen collected in Iowa by Wood is linear-lanceolate, acute, falcate, 8 cm. long; the other, collected by Engelmann in St. Louis, is 45 cm. long. "Doubled" flowers in which the outer stamens become petaloid have been collected at Lancaster and Harrisburg, Pa., by Prof. Porter; at West Troy, N. Y., by Wibbe; and at Cooperstown, N. Y., by Miss Keyes, in 1886.

Form a. — Dioecious; leaves longer than broad, 15 to 30 cm. long, from ample, broadly ovate, obtuse, to linear lanceolate, gradually acuminate; scape simple or branched; bracts ovate, obtuse, 8 to 15 mm. long, glabrous. — From New Brunswick to Minnesota, Louisiana and South Carolina. It includes *S. obtusa* Willd., *S. variabilis obtusa*, Engelm., and *S. hastata* Pursh.

Specimens examined from New Brunswick (Macoun, 1876, Cambellton); Ontario (Macoun, 1873, Hastings Co.; 1877, Belleville; 1884, Nation River); New Hampshire (Deane, 1889); Connecticut (Eaton); New York (Torrey; Gray; Trelease); Pennsylvania (Canby); New Jersey; Delaware (Durand); South Carolina (Ravenel); Kentucky (Short); Louisiana (Hale); Missouri (Engelmann; Bush, 1891); Illinois (Engelmann; Hitchcock); Indiana; Michigan (Engelmann, Ontonagon; Schneck, 1881); Wisconsin (Trelease; Ballard, 666, 739, 1891, Waconia); Minnesota (Dewart, 1888; Dr. Mearns, 673, 674, 1888, Ft. Snelling; Sandberg, 1881, Vasa; Bailey, 151, 1886, Vermillion Lake; Oestland, 1886, Minnehaha; Ballard, 1891, 607, 731, 808, 830; Sheldon, 1892, 3061, 3256); S. Dakota (Williams, 1892); Iowa (Arthur; Hitchcock, 1890); Nebraska (Rydberg, 1887, 1890, Wahoo); Kansas (Pellet, 1890, Johnson Co.; Hitchcock, 1892, Medicine Lodge).

Form b.— Leaves large, 1 to 4 dm. long, the lobes from lanceolate to broadly ovate, apex obtuse, or abruptly acute, basal lobes acuminate, divaricate; scape simple or branched; bracts scarious, 5 to 10 mm. long, ovate, obtuse; achenium 3 mm. long with rather tumid dorsal wing, and long horizontal beak, subepidermal resin passages usually present on each face.— From Washington to Southern California.

Plants from central to southern California with very large leaves about as wide as long, and smooth, usually branched monoecious scape, form the *S. Chinensis* or *Sinensis* of Parish and other collectors, but are not synonymous with the Asiatic *S. Sinensis* Sims. The edible tubers are used by the Chinese.

Specimens of this examined were: 1367, Wilkes Exploring Expedition, 1838–1842, Sacramento Valley; Brewer, 2189, 1861, Pitt River, among the tules; Kellogg, near San Francisco; Jepson, 1891, Grand Island, Lower Sacramento R.; Parish, 2091, 1889 and 1893, San Bernardino, the latter probably introduced from farther north.

From northern California to Washington the common form has narrower rather coriaceous leaves, and dioecious scapes. The edible tubers,* (called Wappatoo), were formerly staple articles of commerce among the Indian tribes along the Columbia river and its tributaries.

Specimens of this examined from California (Moore, Grass Valley; Mrs. Austin, 1878, Plumas Co.); Oregon (E. Hall, 502, 1871; Collier, Eugene City); Washington (Drake and Dickson, 1883; Suksdorf, 673, 1885, —2261, 1890, Kirkland; C. V. Piper, Seattle, 1892).

Form c.— Monoecious or dioecious; leaves 5 to 10 or 15 cm. long, the middle lobe ovate lanceolate or lanceolate, rounding to the acute apex, basal lobes narrower and often shorter, lanceolate, acute or acuminate and widely divergent; verticils few, 2 to 5; the short fertile pedicels about $\frac{2}{3}$ the length of the sterile; bracts ovate, acute, 5 to 10 mm. long; fruiting head about 15 mm. in diameter; achenium 2.5 to 3 mm. long. Phyllodia frequently present, either petiole like or flattened and linear lanceolate. This includes the varieties of *variabilis: hastata*, *angustifolia*, *gracilis* and *diversifolia* of most collectors.— Most abundant in the region of the Great Lakes and northwards. It ranges from Prince Edward Island to British Columbia and southward to New York, Kentucky and Nebraska. Immature or

* See History of the Exped. Lewis and Clarke, Revised and Abridged Ed. by A. M'Vickar, 2: 85, 103, 107, 171, 368 (1842). Hooker Fl. Bor. Amer. 2: 167 (1840).

phyllodial forms are difficult to distinguish from *S. arifolia* except by the longer style, and lateral beak of the achenium.

Specimens examined from Prince Edward Island (Macoun, 1888); New Brunswick (Chadborne, 1883); Quebec (Northrop, 1887, Detour du Lac, Lake Penniscouta); Vermont (Deane, 1885, Willoughby Lake; Rusby, 1892; Morong, 1885, Ferrisburgh, with lanceolate attenuate phyllodia 1 dm. long, and floating leaves 3 cm. long); New York (Engelmann, St. Lawrence River below Ogdensburg, with almost sessile staminate flowers; Sartwell, Penn Yan, with fertile pedicels only 5 mm. long; Clinton, Alexander's Bay, with floating lanceolate leaves 3 to 5 cm. long, and clustered lanceolate phyllodia; Engelmann, 1856, Table Rock, Niagara); Pennsylvania (Wolle, Bethlehem, the form *communis* of Engelmann); Ohio (Riehl, 1836); Kentucky (Rafinesque; Short, 1840); Michigan (Farwell, 419, 1886, and 460, 1890); Ontario (Macoun, 1873, Bay of Quinte, "*hastata* form *c.*;" Bell, 1878, Missinaiba River, "*hastata* form *c*".); Manitoba (Bourgeau, 1858, Lake Winnipeg; Macoun, 1884, Lake Winnipeg, *hastata* form *b.*); Minnesota (Pitcher; Wood, 1889; Ballard, 163, 831, and 897, 1891, and 1074, 1892; Sheldon, 921, 1891, Sleepy Eye, and East Battle Lake, 1892; Taylor, 642, 1891, Minnesota Lake); S. Dakota, (Duffey 1889); Nebraska (Rydberg, 1887, Wahoo, 1890, Lodge Pole Cr., 1891, Scotts Bluff and Deuel Counties, and 1533, 1812, 1893, Hooker Co.); Saskatchewan (Bourgeau, 1858); British Columbia (Macoun, 1889, mouth of Fraser River, "*hastata* form *b.*;" Lyall, 1858, 49th parallel, Oregon Boundary Survey).

Form d.— Monoecious, very slender, 20 to 25 cm. high; leaves 8 to 10 cm. long, the lobes narrowly linear, divergent; fertile pedicels 10 to 15 mm. long; verticils rather remote; fruiting head 1 cm. in diameter.— In the mountains, New York to New Hampshire.

Specimens examined from New York (Mrs. C. Van Brunt, 1886, Balsam Lake, Catskill Mts.; Torrey); Vermont (Dr. Chapman, Lake Dunmore); New Hampshire (Deane, 1883 and 1884, Shelburne, the *variabilis angustifolia* of S. Watson, but not of Engelmann).

Form e. — Monoecious, erect, 4 to 10 dm. high, with the habit of typical *latifolia;* lower leaves sagittate, the upper ovate-lanceolate, acute at both ends, the largest 10 cm. long and 4 to 5 cm. wide; achenium 3.5 mm. long, dorsally crested, with the beak somewhat recurved at the tip.— Collected by Dr. Engelmann on the American Bottoms, opposite St. Louis, in 1856. This form is the *S. variabilis*

diversifolia of Engelmann. Specimens called *diversifolia* by collectors are, without exception, phyllodial or immature plants, from deep or running water, and belonging mostly to form *c*.

S. LATIFOLIA PUBESCENS (Muhl.) J. G. Smith, Mem. Torr. Bot. Club, Vol. **5**: 25 (1894). *S. pubescens* Muhl. Cat. 86 (1813). *S. sagittifolia* var. *pubescens* Micheli in DC. Monog. Plan. **3**: 69 (1881). *S. variabilis* var. *pubescens* Engelm. in A. Gray, Man. Ed. 5, 493 (1867).

Monoecious or dioecious, erect, 3 to 5 dm. high; leaves 7 to 15 or 25 cm. long, broadly ovate, rounding to the abruptly acute apex; bracts and sepals ovate, obtuse, pubescent or woolly; leaves, and especially the scape, from puberulent or minutely hirsute to densely pubescent; scape often very slender; achenium 2 to 3 mm. long; fruiting head 8 to 15 mm. in diameter; fertile pedicels as long as or shorter than the sterile. — Ontario to Florida, from the mountains to the coast. There are three quite well marked forms. — Plate 8.

Form a. — Habit of form *a* of the species; leaves large, obtuse; achenium costate-angled, 3 mm. long. This undoubtedly represents Muhlenberg's type.— From Delaware northward.

Specimens examined from Ontario (Macoun, Bay of Quinte, 1877, very close to form *a* of the species, but with pubescent bracts); Pennsylvania (Darlington; Canby, Chester Co., 1863); Delaware (Canby, 1863).

Form b. — Leaves smaller, 7 to 15 cm. long, light green, sub-coriaceous; bracts and sepals densely pubescent; achenia 2.5 mm. long, smooth on the sides. — The common form in the mountains from Virginia southward.

Specimens examined from Virginia (A. H. Curtiss, 1871; Small, 1892; Britton and Vale, 1892); North Carolina (Rugel, 1842; J. D. Smith, 1881; McCarthy, 101, 1885; Boynton, 1888; Kofoid and Beardslee, 1891); South Carolina (Ravenel, 1869).

Form c. — Scape simple, slender, with the fertile pedi-

cels about equaling the sterile; leaves small, thin and papery in texture; pubescence less dense; achenia about 2 mm. long. Mature specimens have not yet been collected.— Georgia, Florida and Alabama.

Specimens examined from Georgia (Dr. Wray, Augusta); Alabama (C. Mohr, Montgomery and Mobile); Florida (Mary C. Reynolds, 1877, St. Augustine).

S. ENGELMANNIANA n. sp. J. G. Smith in Mem. Torr. Bot. Club. Vol. 5: 25 (1894). *S. variabilis* var. (?) *gracilis* S. Wats. in A. Gray, Man. Ed. 6, 555 (1889) in part, not Engelm.

Monoecious, slender, erect or ascending, 2 to 4 dm. high, glabrous; leaves 8 to 20 cm. long, the lobes linear, 1 to 5 mm. wide, apex rounded or acute, basal lobes acuminate; scape simple, striate, equaling the leaves; verticils 4 to 6, the lower fertile; bracts lanceolate, acute, 8 to 12 mm. long; flowers 2 to 3 cm. wide; petals white, rounded, entire, with a very short claw; sepals short, ovate, acute; stamens 18 to 25; pistils numerous, the style nearly twice as long as the ovary; pedicels slender, ascending, the fertile 10 to 14 mm., the sterile 10 to 20 mm. long; achenium narrowly obovate, 4 mm. long, the stout erect beak $\frac{1}{4}$ to $\frac{1}{3}$ the length of the achenium, entire-winged on both margins, with 1 to 3 strong lateral wings extending downward from the base of the beak on each side; fruiting head globose, 12 to 14 mm. in diameter.— Rare, in shallow ponds, from Massachusetts to Delaware and Florida (?). Dedicated to Dr. George Engelmann, by whom it was collected at Lake George, New York, in 1856.— Plate 9.

Specimens examined from Florida (?) (Chapman, in Herb. Columbia College); Delaware (specimens labeled *S. variabilis graminifolia*, in both the Engelmann and Bernhardi Herbaria); New Jersey (Diffenbaugh, 1864, Brown's Mills, labeled *S. variabilis gracilis;* Britton, 1889, Ocean Co. "*S. variabilis gracilis*"); New York (E. S. Miller, Wading R., Long Island); Massachusetts (Robbins, Sept. 1864, Uxbridge, the *S. variabilis gracilis* of many herbaria; Deane, 1888, Hyannis, and Barnstable; Sturtevant, 1890, S. Framingham).

S. LONGIROSTRA (Micheli) J. G. Smith in Mem. Torr. Bot. Club, Vol. **5**: 26 (1894). *S. sagittifolia* var. (?) *longirostra* Micheli, in DC. Monog. Phan. **3**: 69 (1881).

Monoecious, erect, 4 to 8 dm. high; leaves ample, smooth, 10 to 25 cm. long, middle lobe broadly ovate-rounded, abruptly acute; basal lobes ovate, acute; scape simple, exceeding the leaves, 6-angled below, 6 channeled above in fruit, and minutely scabrous on the angles; bracts 15 to 30 mm. long, triangular, acuminate; fertile pedicels ascending, 1 cm. long or less; pistils numerous, the curved style about twice the length of the ovary; achenium 4 mm. long, broadly obovate with a stout erect recurving beak, broadly winged on both margins, the ventral entire, the dorsal irregularly crenate, a single broken wing or crest on each face; fruiting head depressed globose, 12 to 18 mm. in diameter, subsessile. — Margins of ponds, from southeastern Pennsylvania and New Jersey to Alabama. This is the *S. variabilis echinocephala* of the Engelmann Herbarium.—Plate 10.

Specimens examined from Pennsylvania: (Wm. M. Canby, Aug. 1863, Delaware Co., and Oct. 1863, Chester Co.; T. P. James, 1848, West Philadelphia); New Jersey (James, 1848, near Camden); Delaware (Canby); Kentucky (Kearney, 187, Aug. 1893, Harlan County); Alabama (Drummond, a few flowers in the Engelmann Herbarium from the type specimen of the Kew herbarium).

* * * Achenium quadrate obovate, almost beakless; filaments longer than the anthers; basal lobes more than half the length of the leaf; bracts slightly connate.

S. LONGILOBA Engelm. in Torr. Bot. Mex. Bound. Surv. 212 (1858). *S. sagittifolia* var. *Mexicana* Mart. and Gal., Bull. Acad. Roy. Brux. **9**: 379 (1842), not *S. Mexicana* Steud.

Monoecious, slender, erect, 3 to 5 dm. high; leaves 10 to 18 cm. long, the linear-lanceolate, tapering, acuminate basal lobes 2 to 3 times as long as the acute, linear to ovate-lanceolate middle one; scape simple or rarely branched; verticils 4 to 8, 1 to 3 lower ones fertile; bracts lanceolate, acuminate, 6 to 8 mm. long; fertile pedicels slender, diva-

ricate, 15 to 35 mm. long, exceeding the sterile; stamens 15 to 21; achenium 2 mm. long, narrowly winged on both margins and costate from the base of the beak above, subepidermal resin passages usually present; fruiting head 10 to 12 mm. in diameter; seed obovate, 1 mm. long, the seed-coat punctate. — Margins of shallow ponds, from western Kansas and eastern Colorado south to Texas, New Mexico and Sonora. — Plate 11.

Specimens examined from Kansas (Kellerman, Gove Co., 1885; Hitchcock, 1892, in Ford, Seward and McPherson counties); Oklahoma (Carleton, 262, 1891, Cherokee Outlet); Colorado (Fendler, 850, 1847, Arkansas R.; Beckwith and Gunnison, 49, Upper Arkansas R.); Texas (Lindheimer, June, 1847, Pierdenales; Wright, 680, and 1140, 1849); Mexico (Palmer, 1889, Lerdo, Sonora, specimens with winter tubers attached).

S. Greggii n. sp.

Monoecious, stout, erect, 10 to 14 dm. high; leaves 20 to 40 cm. long, the lanceolate, acuminate, widely divergent basal lobes longer than the lanceolate or ovate and acuminate middle one; scape erect, 5-angled below, paniculately branched from the lowest verticils, exceeding the leaves; branches slender, striate, ascending; verticils numerous, the lower fertile; bracts lanceolate, acuminate, 15 to 25 mm. long; fertile pedicels 15 to 30 mm. long, about as long as the sterile; sepals minutely scabrous; stamens 30 or more, 4 to 5 mm. long; fruiting heads globose, 8 to 15 mm. in diameter; achenium 2 to 3 mm. long, tumid crested on both margins, from obovate with the ventral margin nearly straight to almost circular, edges acute, sides with an irregular saucer-shaped wing, and more or less tubercled; seed 1 mm. long, smooth.—In ponds and ditches, California and Mexico. Collected by J. A. Sanford, July 1893, Stockton, Cal.

The species is dedicated to Dr. J. Gregg, whose No. 833, collected in May 1849, at Zamora, Michoacan, Mexico, seems to be the same as our Californian plant. — Plate 12.

§§ *Fluitantes:* Leaves floating or submerged; fertile pedicel or pedicels thickened and reflexed in fruit, longer than the sterile; bracts at first

connate to the apex, and spathe-like; filaments dilated, bottle-shaped, not pubescent; anthers suborbicular.

S. SUBULATA (Linn.) Buchenau, Abh. Nat. Ver Bremen, **2**: 490 (1871). *Alisma subulata* L. Sp. Pl. 343 (1753). *S. pusilla* Nutt. Gen. **2**: 213 (1818). *S. natans* var. *lorata* A. Gray, Man. Ed. 5, 494 (1867), not Chapm.

Monoecious, with 1 or 2 flowers of the lowest verticil fertile, or all staminate; low, 5 to 15 cm. high, usually with rigid, obtuse or acutish phyllodia, or rarely with linear-lanceolate, subacute blades 2 to 3 cm. long, narrowing at the base into a spongy petiole; scape simple, equaled or exceeded by the leaves, few flowered; flowers rather large for the size of the plant, 15 mm. across; sepals ovate-lanceolate, obtuse; fertile pedicels 10 to 15 mm. long; bracts acute; stamens 7 or 8, less than 2 mm. long, the filaments equaling the anthers; achenia rather few, nearly 2 mm. long, 3-crested, with a short and slender, abrupt lateral beak and a short, fusiform resin passage down the middle of each face; fruiting head small.— In mud, tide-water flats from New York to Florida and Alabama. — Plate 13.

Specimens examined from New York (Sartwell; Torrey; A. Gray, Albany); Pennsylvania, New Jersey and Delaware, shores of the Delaware (Martindale; Conrad; Zanzinger, 1844; Durand, 1848; Tatnall, 1860; Austin, Hackensack; Smith, 1867); Maryland (Canby, Saulisbury, 1863; Porter, Port Dupont); District of Columbia (S. Watson, 1871; Seaman, 1872); Virginia (Dr. Robbins, shores of the Potomac; L. F. Ward, Custis Spring, 1877 and 1878); North Carolina (M. A. Curtis, 1843); Georgia (Baldwin); Florida (J. D. Smith, 1884, Magnolia, Clay Co.), Alabama (Charles Mohr, shores of Mobile Bay). Flowering from July to September.

S. SUBULATA NATANS (Michx.).— *S. natans* Michx. Fl. Bor. Am. **2**: 190 (1803). *S. natans* var. *lorata* Chapm., Flora S. U. S., 449 (1860).

Larger, submerged plant with ovate-oblong, elliptical, or subcordate, or truncate-hastate, floating leaves, with broader and longer flattened phyllodia; scape and pedicels elongated,

the flowers opening at the surface of the water or raised above it; bracts acuminate; fruiting head larger, 8 mm. in diameter; filaments longer; achenia more numerous, 2 mm. long, 5- to 7-crenately crested.— Flowering from August to October. In fresh water ponds and brackish tide waters along the coast from South Carolina to West Florida. Specimens from the coast of Florida have the petioles, phyllodia and floating scape much elongated, the latter often 8 to 10 dm. long. Figured from a specimen collected in West Florida by Dr. Leavenworth with both the floating leaves ascribed to *natans*, and the ribbon-like phyllodia of *lorata*. — Plate 13.

Specimens examined from "Carolina" (Bernhardi Herbarium); "Southern States" (Read, 1856; Baldwin); South Carolina (Ravenel, Santee Canal); Alabama (Mohr); Florida (Croom, 1835, Quincy; Dr. Chapman, 218, Apalachicola, and many specimens without date or locality in many herbaria; Dr. Leavenworth, at St. Marks, "where the water varies in depth with the tide from 2 to 5 or 6 feet," and Ft. Duane, East Florida; Keeler, Mayport and Jacksonville; and Curtiss, 2747, 1878, Jacksonville).

S. SUBULATA GRACILLIMA (S. Wats.) J. G. Smith, in Mem. Torr. Bot. Club, Vol. **5**: 26 (1894). *S. natans* var. (?) *gracillima* S. Wats. in A. Gray, Man. Ed. 6, 556 (1890). *S. natans* Engelm. Bull. Torr. Bot. Club, **9**: 4 (1882).

Submerged aquatic; leaves 6 to 12 dm. long, usually consisting of narrow flexuous phyllodia 2 mm. wide, indistinctly 1-nerved toward the apex, or widening into a 3-nerved, lanceolate blade 3 to 4 cm. long, 6 to 8 mm. wide; scape simple, terete or flattened, as long as the leaves, bearing 2 to 6 verticils; pedicels 3 to 10 cm. long; only 1 or 2 flowers appearing at the surface of the water at a time, 15 to 20 mm. across; inflorescence at length 4 to 5 dm. long; bracts acute, soon evanescent; the immature achenium broadly obovate, with a stout oblique beak. The achenia ripen under water and mature specimens have not yet been collected.— In deep water of streams in Eastern Massa-

chusetts and Rhode Island. Flowering late in July.—Plate 14.

Specimens examined from Massachusetts (Hitchings, July 22, 1870, Milton, and 1877, Readville; Boott, July 28, 1870, Readville; C. E. Faxon, July, 1877, Charles and Neponset Rivers, and 1882, Dedham; Edwin Faxon, 1891, Readville; Deane, 1890, Milton); Rhode Island (Collins, 1890, Ten Mile River).

S. FILIFORMIS n. sp.

Submerged aquatic, with linear, filiform phyllodia 1.5 to 6 dm. long, 2 to 3 mm. wide; scape slender, filiform, 6 to 12 dm. long, branching from all but the uppermost verticils; bracts lanceolate, acuminate, 3 to 5 mm. long, at length evanescent; pedicels and branches of the scape filiform, 4 to 10 cm. long; 1 or 2 flowers of the lowest verticil pistillate, the rest all staminate; verticils 6 to 10, remote; flowers 10 to 12 mm. wide; sepals ovate, obtuse, scarious margined; petals white; stamens 7; filaments over twice as long as the anthers; mature achenia not yet collected; ovary obovate, equaled by the slender oblique style. — Floating in still water, Dog River, Mobile County, Alabama, Mohr, August 14, 1893. One of the specimens is proliferous at the lowest verticil of the scape, throwing out roots, phyllodia and flowering pedicels from the axils of the bracts.—Plate 15.

More or less imperfect specimens of this are: Curtiss 31, Long Moss Spring, Jackson Co., and Jacksonville, Fla.; plants collected by Chapman, 1842, near Apalachicola; and by Keeler near Jacksonville. These were all distributed as *S. graminea*.

§ § § *Integrifoliae*. Leaves entire or hastate, from linear to ovate, neither sagittate nor floating; bracts free or connate at the base; stamens 12 or more; filaments slender, or dilated and pubescent.

* Fertile pedicels neither thickened nor reflexed in fruit.

+ Achenium falcate, obovate, with an oblique beak; leaves lanceolate, entire, pseudo-penninerved; stamens more than 20; filaments slender as long as or longer than the linear oblong anthers.

S. LANCIFOLIA Linn. Amoen. 5: 409 (1760). *S. lancifolia* var. *major* Micheli, in DC. Monog. Phan. 3; 73 (1881).

Rigid, erect; leaves 4 to 9 dm. high, the blades coriaceous, 30 to 60 cm. long, 5 to 10 or 20 cm. wide, acute or long acuminate, 5- to 9-nerved, gradually narrowing to the base and decurrent into the petiole, pseudo-penninerved (the primary nerves separating from the thickened midrib above the base), scape erect, striate, branched, exceeding the leaves, often 1.5 to 2 m. high; verticils very numerous; fertile pedicels ascending, shorter than the sterile, 1 to 3 cm. long; bracts glabrous, free, ovate, acute or acuminate, 10 to 25 mm. long, before flowering enfolding the buds at the apex of the scape, with the free tips turned outward; flowers ample; sepals smooth; petals obovate, white; stamens numerous; anthers oblong, twisted after dehiscence, about as long as the cobwebby-pubescent filaments; staminodia present in the pistillate flower; achenium 2 to 3 mm. long, winged on both margins, a short vertical resin passage on each side; beak short.— From Florida (and Texas, *fide* Micheli) southward, throughout the West Indies, Mexico, Central and South America. Very variable as to its achenial characters, and the length of bracts and stamens.— Plate 16.

Specimens examined from Florida (Canby, 1869, Hibernia; Powell, 1872; Keeler, Jacksonville; Bates, 1889, Merritts Island; Simpson, 1890; Hulst, 1891, De Land; Curtiss, 2742, Jacksonville; Buckley; Burrowes).

S. LANCIFOLIA FALCATA (Pursh) J. G. Smith, in Mem. Torr. Bot. Club, Vol. 5: 25 (1894). *S. falcata* Pursh, Fl. Am. Sept. 397 (1814).

Rigid, erect, smaller than the species; leaves narrower, nerves 3 to 5; scape less branched, often simple; fertile pedicels shorter, 8 to 20 mm. long; bracts short, 5 to 8 mm. long, ovate, obtuse or sub-acute, more or less granular papillose on the back; filaments cobwebby pubescent, longer than the anthers; achenium about 2 mm. long,

winged on both margins, the resin passages more prominent.— From Delaware to Florida, Texas and Mexico.— Plate 16.

Specimens examined from Maryland (Canby, 1872, Saulsbury; Rusby, 1889, Stockton); Delaware (Canby, 1887, Seaford); Virginia (Rugel); North Carolina (McCarthy, 1885, Wilmington); South Carolina (Ravenel, Santee Canal); Carolina (Pursh, achenia from the type, in Herb. Engelmann, ex Herb. Hooker); Florida (Deane; Chapman, Apalachicola; Canby, 1879, Hibernia); Alabama (Mohr. 1879); Mississippi (Hilgard, 1859, sea coast marshes; Tracy, 2175, 1893, Biloxi); Louisiana (Lindheimer, 1839, Lake Pontchartrain; Dr. Hale); Texas (Lindheimer, 1842, Galveston Bay); Mexico (Rovirosa, 675, 1889). Many Mexican and Central American specimens have connate bracts, but are in other particulars identical with this variety.

S. AMBIGUA n. sp.— *S. lancifolia* Kellerman Anal. Flora Kansas, 178 (1888).

Erect, 3 to 6 dm. high; leaves lanceolate, long-acute, gradually narrowing to the base, not decurrent, 12 to 20 cm. long, 5-nerved; scape erect or ascending, simple or branching from the lowest whorl, equaling or exceeding the leaves; verticils numerous, 8 to 12 or more; bracts lanceolate, acuminate, connate at the base, sparsely papillose on the nerves, 10 to 15 mm. long; fertile pedicels ascending, 2 to 4 cm. long, longer than the sterile; stamens 20 to 25, the slender glabrous filaments longer than the oblong anthers; fruiting head depressed globose, 12 to 15 mm. in diameter; achenium 2 mm. long, narrowly falcate, almost beakless, very narrowly winged on both margins, the sides smooth, with 2 or 3 resin passages.— In ponds. Central Kansas and Oklahoma. Apparently first collected by Dr. Butler, 1875, in the Indian Territory. Also collected in McPherson Co., Kansas, by J. E. Bodin, July, 1887; and by A. S. Hitchcock, July 29, 1892, in fruit.

This species has been distributed as *S. lancifolia* but differs in having papillose, connate, lanceolate bracts, glabrous filaments, and almost beakless and wingless falcate achenia.— Plate 17.

+ + Achenium narrowly obovate, with a long, stout, erect beak; leaves hastate, veins free to the base; filaments dilated, pubescent; anthers short-oblong; fertile flowers subsessile.

S. RIGIDA Pursh, Fl. Am. Sept. 397 (1814). *S. heterophylla* Pursh, l. c. 396 (1814). *S. heterophylla* var. *angustifolia* Engelm. in A. Gray; Man. Ed. 5, 494 (1867), and var. *elliptica* Engelm. l. c. 494 (1867).

Monoecious, erect or ascending, 1 to 8 dm. high; leaves 5 to 20 cm. long, varying from elliptical, linear or lanceolate to broadly ovate, apex acute or abruptly rounded, base entire, or cordate, or with 1 or 2 narrow divergent lobes, veins 7 to 9; scape simple, weak, sinuous, at length decumbent, shorter than the leaves, usually geniculate at the lower verticil; bracts ovate, obtuse, 4 to 8 mm. long, deeply connate; 1 or rarely 2 verticils fertile, the pedicels not exceeding 1 cm. long; filaments usually exceeding the anthers; achenium narrowly winged on both margins, 3 to 4 mm. long, crested above; fruiting head echinate with the beaks of the achenia, 8 to 15 mm. in diameter, almost sessile.— In stagnant or running water, rooting in the mud. Quebec to Tennessee, west to Minnesota and Nebraska.— Plate 18.

Specimens differ greatly in size and form of leaf, differences depending largely on the habitat of the plant. When growing in deep pools or running streams, the petioles become thick, rigid and elongated, with long narrowly lanceolate spongy blades, or the tapering attenuate phyllodia are bladeless. This is the *S. heterophylla rigida* of the manuals and collectors. When growing in shallow ponds or in simply muddy places, the petioles are weaker, and the blade elliptical ovate and usually smaller, and the habit erect or ascending. This form is the *S. heterophylla elliptica* of collectors. Depauperate plants from shallow water or simply muddy places, with linear elliptical oblong leaves, are the *S. heterophylla angustifolia* of collectors. Toward the southern limit of its range, the plants are usually of ranker growth, with larger more often

hastately lobed leaves. In all these conditions there is much variation in form and size of achenium, stamen length, and in the size of the fruiting head. They occur together throughout the range and seem to be the result of different habitat, rather than to mark distinct forms or varieties.

Specimens examined from Vermont (Pringle, 1879; Faxon, 1882; Morong, 1885); New York (Dr. Pitcher, 1829; Sartwell, Penn Yan; Ward, 1879; Clinton, in the rapids above Goat Island, Niagara; Engelmann, 1840, 1856; Robbins, 1866; A. Gray); Connecticut (Wright); Pennsylvania (Porter; Guttenberg, 1879; James, 1860; Britton, 1889); New Jersey (James, 1848; Porter, 1860; Morong, 1891; Beyrich); Delaware (Tatnall, 1860); Ohio (Riehl, 1835, 1836; Engelmann; Riddell, 1868; Werner, 1887); Kentucky (Rafinesque); Tennessee (Gattinger, 1883); Illinois (Riehl, 1846; Engelmann, many dates and localities; Brendel, 1873; Eggert, 1877; Hitchcock, 1891; Bush, 1892); Iowa (Hitchcock, 1888); Nebraska (Williams, 1890; Smith, 1890; Rydberg, 1891; Bates, 1891, 1893, Sand Hills); Minnesota (Sandberg, 1885, 1890, 624 and 633, 1891; Herrick, 1878; Bailey, 542, 1886; Ballard, 273, 588, 814, 1891; Sheldon, 321, 1891, and 3149, 3211, 1892); Wisconsin (Houghton, 1831; Robbins, 1866); Michigan (Bigelow, 1865); Ontario (Macoun, 1868, 1884); Canada (Pursh).

+– +– +– Achenium obovate, with a short lateral beak; filament dilated at the base, pubescent; bracts connate, glabrous.

S. GRAMINEA Michx. Fl. Bor. Am. **2**: 190 (1803). *S. acutifolia* Pursh, Fl. Amer. Sept. 397 (1814). *S. simplex* Torr. Comp. 356 (1826), not Pursh. *S. sagittifolia* var. *simplex* Hook. Fl. Bor. Amer. **2**: 167 (1840). *S. Purshii* Kunth, Enum. **3**: 160 (1841). *S. stolonifera* Engelm. and Gray, Boston Journ. Nat. Hist. **5**: 234 (1847).

Monoecious or dioecious, 1 to 6 dm. high; leaves lanceolate to ovate elliptical, acute at both ends; or *very rarely* truncate or hastate with short divaricate lobes at the base, 1 to 6 cm. wide, 5 to 15 cm. long, 3- to 5-nerved, the nerves free to the base; scape simple, slender, erect, with few remote, or many verticils sometimes approximate; bracts ovate, acute, 3 to 5 mm. long, connate to the middle; fertile and sterile pedicels about equal, spreading, 1 to 3 cm.

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long; stamens about 18; anthers exceeding or equaling the filaments; achenium 1.5 mm. long, dorsally crested and obliquely unicostate or winged on the sides, with or without subepidermal resin passages; fruiting head small, 5 to 10 mm. in diameter. Phyllodia, when present, flattened, linear lanceolate, acute, 8 to 30 cm. long, 1 to 2 cm. wide. Plants producing winter tubers and growing in tufts at the nodes of horizontal stolons.— In shallow ponds and marshes, or slowly running streams, or in simply muddy places. From New Foundland westward to the Missouri river, and south to Florida and Texas. In the southern portion of its range it passes into the next variety. — Plate 19.

Specimens examined from Canada (Michaux; Macoun, 1883, Cape Breton; Britton and Timmerman, 1889, L. Muskoka); New Brunswick (Macoun, Little Tobique River, 1884); New Hampshire (Deane, 1884, Shelburne); Massachusetts (Robbins, Uxbridge, 1865 and 1866; A. Gray, Newburyport, 1866; G. E. Stone, Worcester); New York (Dr. Sartwell, Penn Yan; A. H. Curtiss, Lake Oneida; J. A. Paine, Herkimer Co., 1854; Ward, South Bend, 1879; Vasey, Lake George, 1882; Morong, New York City, 1891); New Jersey (Durand; Bergen, 1845; Britton, Branchville, 1886); Delaware (Tatnall, 1860; Durand; Brinton, Townsend, 1890; James, 1867); Pennsylvania (Moser, Bethlehem, 1832; Wolle, Bethlehem, 1856; Porter, Harrisburg, 1863; James, Philadelphia, 1861 and 1867); West Virginia (Millspaugh, Hinton, 1891); Michigan (Dr. Bigelow, Detroit, 1865); Ontario (Macoun, Petersboro Co., 1878); N. W. Terr. (Macoun, 208, Eagle Hills, 1879); South Dakota (Williams, Big Stone Lake, 1892); Iowa (Hitchcock, Consforth, 1890); Nebraska (Swezey, 136, Hardy; Rydberg, Mead, 1890; Smith, Lincoln, 1890; Bates, Holt Cr., 1892); Kansas (Oyster, Paola, 1891); Missouri (Engelmann, many dates and collections, 1832 to 1880,— specimens collected at St. Louis in 1857 have the leaves truncate or divaricately hastate lobed at the base; Eggert, St. Louis, 1875; Pammel, Valley Park, 1886; Bush, Courtney, 1891; Jackson Co., 1892); Illinois (Engelmann, many dates and collections from 1832 to 1880; Meyer, East St. Louis, 1838; Vasey, Ringwood; E. Hall, Athens, 1861; Eggert, St. Clair, 1875; S. Watson, Quincy, 1885; Hitchcock, Fish Lake, 1890); Kentucky (Dr. Short, Lexington, 1835 and 1840), North Carolina (Schweinitz); South Carolina (Ravenel, Santee Canal); Georgia (Curtis, Atlanta 1850); Alabama (Mohr, Mobile, 1883, 1884); Southern States (Dr. Leavenworth; Dr. Walsh); Florida (Alden, Ft. King; Harding, Baker Co. 1887; Hulst, DeLand, 1891); Louisiana (Carpenter, 1839; Hale); Texas (Lindheimer, West of the Brazos, 1839, and 183, 1843 at Houston, *S. stolonifera* Engelm. and Gray, plants with linear lanceolate, acute acuminate phyllodia 1 cm. wide, 3 to 4 dm. long; Bigelow, San Bois, 1853;

Drummond, 434, 435 and 436; Dr. Bigelow, Whipple's Exped., Shawnee villages, 1853).

S. GRAMINEA CYCLOPTERA n. var.

Slender, erect, 2 to 8 dm. high, from a horizontal or oblique rhizome; leaves linear lanceolate, tapering gradually at both ends, or reduced to slender attenuate phyllodia; scape simple or branching from the lowest verticil; internodes longer than the fertile pedicels; bracts and stamens as in the species; achenium 1.5 mm. long, with an abrupt dorsal crest, an arched wing, and a median vertical resin passage on each side, or when maturing under water only costate or wrinkled.— From South Carolina to Florida and Louisiana.— Plate 20.

Specimens examined from South Carolina (Dr. Mohr, Nov. 1893, Ridgeland); Florida (Dr. Chapman, 234, in Herb. Torrey, and Apalachicola; Curtiss, 1876 and 2746, pine barren ponds, Duval Co.; Keeler, near Jacksonville); Alabama (Mohr, April, 1886, May, 1893, and Aug. 1893, Mobile); Louisiana (Hale, pine barren ponds, in Herb. Engelmann).

S. GRAMINEA CHAPMANI n. var.

Three to five dm. high; leaves narrowly lanceolate, acute, tapering at base into the petiole, 2 to 3 cm. wide, 15 to 20 cm. long; scape weak, branched or simple, the fertile flowers numerous; bracts lanceolate, acute or acuminate, 6 to 12 mm. long, slightly connate at the base; stamens as in the species; fertile pedicels 1.5 to 3 cm. long; fruiting head 5 mm. in diameter; achenium almost beakless, 1 mm. long, with a narrow dorsal crest, the sides not costate nor winged. Phyllodia oblanceolate, long-acute, 1 to 2 cm. wide, 10 to 30 cm. long.— In creeks and stagnant ponds, West Florida and Alabama. Dedicated to the venerable southern botanist, Dr. Chapman, by whom it was first collected in 1862, "in a creek on the road to Marianna, 3 or 4 miles from Ochesee, West Florida." Also collected by Dr. Mohr, 1880, and March, April, May and June, 1884, in the vicinity of Mobile, Alabama. — Plate 21.

S. CRISTATA Engelm. in Arthur's Contributions to the Flora of Iowa, no. 5, 3 (1882). Proc. Davenport Acad. Nat. Sci. **4**: 29 (1886).

Monoecious, slender, erect, 30 to 75 cm. high, submersed or in shallow water; leaves linear-lanceolate or rarely elliptical lanceolate, 6 to 10 cm. long, 1 to 2 cm. wide, thick, spongy, triquetrous in cross section; petioles long and slender; scape simple, erect, the flowers at or above the surface of the water; verticils 4 to 6, the lowest fertile; bracts 5 to 7 mm. long, acute; fertile pedicels ascending, 1.5 to 3 cm. long; flowers about 2 cm. across; sepals ovate, obtuse, scarious tipped, rough on the veins; stamens about 24; filaments dilated subulate, pubescent at the middle, longer than the anthers; achenium 3 mm. long, dorsally crenately crested, ventral margin straight winged, an interrupted crenate crest on each side, beak short; fruiting head globose, 15 to 20 mm. in diameter. Often with tufted phyllodia, flat, linear lanceolate, acute, 1 dm. long. In deep water, the petioles and scape are spongy and rigid. The phyllodia grow from the nodes of the stolons along the muddy bottom, to the depth of 1 or 2 m. or more.— Ponds and lakes, northern Iowa, southern Minnesota and (?) western New York. Engelmann's type specimens were collected by R. I. Cratty, Emmett Co., Iowa, 1881.— Plate 22.

Specimens also examined from Minnesota (Sandberg, 623, Minnetonka, 1891; Herrick, 1878; Aiton, Minneapolis, 1891; Ballard, 603, Scott Co., 1891; Sheldon, 705, White Bear, 1891; Wood, Chub Lake, 1889); New York (?) Dr. Sartwell in Herb. Gray).

S. MACROCARPA, n. sp.

Monoecious, slender, 3 to 4 dm. high, suberect; phyllodia flexuous, 25 to 30 cm. long, gradually expanding above to a linear lanceolate blade 5 to 7 cm. long, 3 to 5 mm. wide; scape slender, equaling or exceeding the leaves, simple; verticils few, 3 to 5, about the length of the pedicels apart; bracts ovate, acute, 3 mm. long, connate; 1 to 3 flowers of lowest verticil perfect, their pedicels slender,

ascending, 6 to 12 mm. long; sterile pedicels 10 to 15 mm. long; stamens about 12, the dilated pubescent filaments a little longer than the short oblong anthers; fruiting head about 12 mm. in diameter; achenia oblong obovate, 3 mm. long, broadly winged on both margins, smooth or faintly unicostate, and with 2 or 3 resin passages on each side, beak short and oblique.—Margin of ponds in South Carolina. Collected by M. A. Curtis in South Carolina (Engelm. Herbarium). Related to *teres* and *cristata*.—Plate 23.

S. TERES S. Wats. in A.Gray, Man. Ed. 6, 555 (1890).

Monoecious, with acute, attenuate, terete, usually nodose phyllodia 10 to 30 cm. long, very rarely bearing a short linear blade; scape slender, erect, simple, 15 to 45 cm. high; bracts ovate, obtuse, 3 mm. long; verticils few, 1 to 3, 1 or 2 flowers of the lowest fertile; fertile pedicels slender, ascending, 10 to 25 mm. long, exceeding the sterile; flowers small, 12 to 15 mm. across; stamens 12, the filaments dilated, pubescent, shorter than the anthers; mature achenium rounded-obovate, 2 mm. long, with a short, erect beak, the ventral margin wing-angled, dorsal margin and sides crenately several- (7 to 11) crested; fruiting head 8 to 12 mm. in diameter.—In shallow water, Massachusetts to South Carolina. Mature achenia collected only by Walter Deane, at Hyannis, Mussachusetts, August, 1888. The immature achenia are dark brown, and barely costate laterally. The fruits usually ripen under water, and do not then assume the same characters as when ripening above water.—Plate 24.

Specimens examined from Massachusetts (Farlow, 1881; Brewster); New York (E. S. Miller, Wading River, Long Island, 1871); New Jersey (Torrey, 1833, pine barrens). Specimens marked A, collected in North Carolina by M. A. Curtis, are intermediate between this species and *macrocarpa*. They have the habit of *teres*, but with larger achenium (2.5 mm.) with smooth sides, and more oblique beak.

+ + + + Achenium short obovate, with a short lateral beak; leaves lanceolate, entire; filament slender, glabrous; bracts connate, densely papillose.

S. PAPILLOSA Buchenau, Abh. Nat. Ver. Bremen, **1**: 44 (1868). *S. lancifolia* var. *papillosa* (Buch.) Micheli, in DC. Monog. Phan. **3**: 74 (1881).

Monoecious, slender, erect, 3 to 5 dm. high; leaves linear lanceolate, acute, gradually narrowing into the slender petiole, 10 to 15 cm. long, 3 to 5 nerved, pseudo-pennineryed toward the base; scape very slender, erect, terete or obtusely 3-angled, striate, simple or branching from the lowest whorl; bracts obtuse, 3 to 4 mm. long, densely granular papillose on the back; fertile pedicels ascending, 1 to 2 cm. long, the sterile 1.5 to 3 cm. long; sepals ovate, obtuse, papillose; flowers 20 to 30 mm. across; stamens 18, about 3 mm. long, the linear oblong anthers equaled or exceeded by the slender glabrous filaments; achenium 1.5 mm. long, with a tumid dorsal crest and a single vertical resin passage on each face; fruiting head globose, 6 to 10 mm. in diameter. — In shallow ponds, Texas and Louisiana. — Plate 25.

This species was placed by Micheli as a variety of *lancifolia*, but is more closely related to *graminea* and perhaps *ambigua*. Fully matured achenia have not as yet been collected, or at least are not present in any of the American herbaria examined.

Specimens examined from Louisiana (Dr. Hale, Pine Barren, Alexandria); Texas (Drummond, 423; Lindheimer, Houston, 1842, a specimen with the foot of the plant bulbous, covered with the bases of the dead leaf sheaths, and 1843, 182; Elihu Hall, 623, 1872, Houston; G. C. Nealley, 1884, Beaumont). Lindheimer says of his Houston specimens that the successive annual tubers are formed one over another, so that a plant often has two or three of the old exhausted ones attached. The leaves are sometimes reduced to linear phyllodia which "resemble flowerless scapes."

* * Fertile pedicels thickened or reflexed in fruit.

+ Achenium obovate; leaves hastate or entire; bracts connate to above the middle, glabrous.

S. PLATYPHYLLA (Engelm.). *S. graminea* var. *platyphylla* Engelm. in A. Gray, Man. Ed. 5, 494 (1867); J. G. Smith in Mem. Torr. Bot. Club, Vol. **5**: 25 (1894).

S. recurva Engelm. Patterson, Check-List, 130 (1887), name only.

Monoecious, erect, 2 to 5 dm. high; leaves subcoriaceous, 5 to 7 pseudo-penninerved from near the base, 5 to 15 cm. long, 2.5 to 9 cm. wide, broadly ovate, or ovate lanceolate, or ovate elliptical, obtuse or acute, abruptly short acuminate at the apex, rounding or gradually narrowing to the base, or rarely subcordate, auriculate or hastate; scape simple, rather weak, ascending, smooth, usually shorter than the leaves; 2 to 4 lower verticils fertile; fertile pedicels thick, divaricate in flower, weak and reflexed in fruit, 12 to 25 or rarely 40 mm. long, mostly longer than the sterile; bracts broadly ovate, 3 to 6 or 8 mm. long; flowers 2.5 to 3 cm. across; sepals ovate, obtuse, scarious at the tip; stamens about 21, the dilated pubescent filaments a little longer than the short oblong anthers; achenium 2 mm. long, obliquely obovate, winged on both margins, with a narrow dorsal crest, laterally with an oblique wing-angle extending downward from the base of the short horizontal or oblique beak; short resin passages usually present between the lateral angle and the crest; fruiting head 9 to 12 mm. in diameter; linear oblong or oblanceolate phyllodia, 10 to 15 mm. wide, 4 to 6 dm. long, often present.— In swamps and ponds from Texas to Mississippi and northward to the "sunken lands" of Southeast Missouri.— Plate 26.

Specimens examined from Texas (Lindheimer, 713, New Braunfels, 1847 and 1851; Reverchon, 1875, and "Curtiss, 2746 *" 1881, and 939, 1880, from Dallas; E. Hall, 624, Hempstead); Louisiana (Fendler, 1846, New Orleans; Dr. Hale, Alexandria and Bayou Robert); Mississippi (A. Wood, 1860); Arkansas (Eggert, 1893, Paragould); Missouri (Bush, 1893, Kennett, Dunklin Co.).

S. Mexicana Steudel, Nom. **2**: 491 (1841). *S. macrophylla* Zucc. in Abh. Kön. Bayr. Akad., 289 (1832), not Bunge; Micheli in DC. Monog. Phan. **3**: 71 (1881). See below, p. 33.

This species is said by Micheli to be represented in the herbarium of

the St. Petersburg Academy, by a specimen collected by Dr. Engelmann at New Orleans. There is in Herb. Engelmann, a very long-pediceled specimen of *platyphylla* from Louisiana which has been mistakenly called *Mexicana*. This is undoubtedly the same as the plant in the St. Petersburg Herbarium. As far as known, S. Mexicana does not occur in the United States.

++ Achenium quadrate cuneate, beak short and triangular; leaves entire, pseudo-penninerved; bracts connate at the base.

S. Sanfordii, Greene, Pittonia, **2**: 158, 1890.

Monoecious, 9 to 15 dm. high, rigidly erect or ascending; petioles rigid, 2 to 4 cm. thick at the base, obtusely triquetrous; blade linear lanceolate to oblong lanceolate, acute, tapering into the spongy petiole; scape simple, stout; bracts triangular, obtuse, 5 to 7 mm. long; verticils numerous, approximate, 2 to 3 lower ones fertile; fertile pedicels 15 to 20 mm. long, reflexed in fruit; sepals ovate, acute, 4 to 6 mm. long; stamens about 20, the oblong anther longer than the dilated glabrous filament; achenia numerous, 2 mm. long, winged on both margins, the sides reticulate, with or without a costate lateral angle; beak short, oblique, triangular; fruiting head 12 to 14 mm. in diameter. Triangular, alternate, spongy phyllodia several decimeters long are present when the plant is nearly or quite submerged. — Growing in the marshes along the lower San Joaquin River, California. Specimens examined from Stockton, Cal., collected by J. A. Sanford, 1891, and 1893. We are indebted to Mr. Sanford for fresh material of this species, and for water color habit sketches drawn under his direction by Dr. Hudson of Stockton.— Plate 28.

B. Fertile sepals erect and accrescent; pedicels of the pistillate flowers thickened and reflexed in fruit; petals cream white with a brownish purple spot at the base. Introduced species.

S. Montevidensis Cham. and Schlecht. Plant. Romanzoff. Linnaea **2**: 156 (1827). Micheli in DC. Monog. Phan. **3**: 75 (1881).

Monoecious; petioles stout, rigid, erect, ascending; leaves sagittate, acute or obtuse, 1 to 5 dm. long and

broad, basal lobes acute, acuminate, widely divergent, glabrous above, sparsely scabrous on the nerves below; scape usually simple, stout, often 6 to 8 cm. in diameter at the base; verticils numerous, more or less approximate, 2 to 4 lower ones fertile; bracts connate at the base, lanceolate, long acuminate, the upper undeveloped portion of the scape appearing comose with their projecting tips; staminate pedicels slender, ascending, 20 to 30 mm. long, longer than the fertile; flowers large, the sepals broadly ovate, obtuse, 10 mm. wide, 15 mm. long; petals obovate, larger than the sepals; stamens very many, the narrow glandular pubescent filaments longer than the linear oblong anthers; achenia 2 to 3 mm. long, narrowly quadrate obovate, winged on both margins, with a short slender, oblique beak, and a prominent sub-epidermal resin passage on each side above; fruiting head large, 15 to 30 mm. in diameter.— A South American species established as a ballast plant in California and North Carolina. Specimens examined from California (J. A. Sanford, July 1893, Stockton); North Carolina (Gerald McCarthy, September, 1888). — Plate 29.

Species from Mexico.

§§ *Fluitantes:* stamens 12 or 13.

S. DEMERSA n. sp.

Submerged aquatic; the floating phyllodia linear attenuate, 2 to 6 dm. long, 10 to 15 mm. thick at the base, tapering gradually to the obtuse apex; scape simple, weak, rising to the surfacc of the water, usually 20 to 30 cm. long; bracts scarious, deeply connate, acute, 3 to 5 mm. long, soon evanescent; verticils 4 to 6, the lowest fertile; fertile pedicels thickened, 10 to 35 mm. long, at length reflexed; sterile pedicels slender, erect-spreading, 10 to 20 mm. long, the flowers at length deciduous, filaments dilated, glabrous, twice as long as the sub-orbicular anthers; fruiting head 5 to 6 mm. in diameter, sub-globose; achenium obovate,

plump, 1.5 to 2 mm. long, with a very slender lateral erect beak, margins broadly winged below the middle, sides smooth; seed 1 mm. long, broadly obovate, striate. — Ponds near Guerrero, Chihuahua, Mexico, Pringle, 1367, Sept. 9, 1887. Distributed as *S. graminea* forma *acutifolia*. It is related to *S. subulata* and *S. filiformis*.— Plate 15.

§ § § Integrifoliae.

* Fertile pedicels neither thickened nor recurved in fruit.

S. LANCIFOLIA ANGUSTIFOLIA (Lindl.) Griseb. Catal. Pl. Cub. 218 (1866); Micheli, DC. Monogr. **3**: 73. *S. angustifolia* Lindley, Bot. Reg. **14**: pl. 1141 (1828).

Much smaller than the type in every part; blade of leaf very narrow or absent; bracts barely 3 mm. long; sepals 3 to 4 mm.; carpels crested,— ex Micheli, *l. c.* 73.— Ticaltepec, Mex., Liebmann, July, 1841, fide Buchenau, Engler's Bot. Jahrb. **2**: 487.

* * Fertile pedicels thickened or recurved in fruit.

S. MEXICANA Steudel, Nomenclator, 491 (1841). *S. macrophylla* Zucc. Abhandl. Bayr. Akad. 1832, 289; Micheli, Monogr. **3**: 71.— not Bunge, Mem. Sav. Etrang., **2**: 137 (1831).— See above, p. 30.

Monoecious, 3 to 10 dm. high; erect, or the petioles weak and ascending; leaf 10 to 20 cm. long, 1 to 5 cm. wide, lanceolate, acute at the apex, entire, abruptly narrowing to the petiole, or hastate with small, nearly linear, divaricate lobes; veins free to the base; scape simple, erect, about equaling the leaves; verticils 3 to 5, remote; fertile pedicels erect-spreading in flower, 5 to 7 cm. long, exceeding the sterile; bracts broadly ovate, obtuse, 8 to 10 mm. long, connate nearly to the apex; flowers ample, 3 cm. across; stamens 21 to 30, 4 to 5 mm. long, the slender glabrous filaments longer than the oblong sagittate anthers. The mature achenia have not yet been collected. In immature fruiting heads, the ovaries are broadly winged,

with a long horizontal style, and an undulate dorsal crest.—Plate 27.

Specimens examined from Mexico, collected by L. Hahn, 1869, in Herb. Engelmann, ex Herb. A. Braun; and a fragment from the type, in Herb. Engelmann, ex Herb. Monaco, collected by Karwinsky.

LOPHOTOCARPUS T. Durand, Index Gen. Phan. 627 (1888). *Lophiocarpus* Miquel, Ill. Fl. Arch. Ind. **1**: part 2, 50 (1870), not Turcz.—Fertile flowers with stamens; filaments hypogynous.

L. CALYCINUS (Engelm.) J. G. Smith, in Mem. Torr. Bot. Club, Vol. **5**: 25 (1894).—*Sagittaria calycina* Engelm. including var *maxima*, var *media* and var. *fluitans* Engelm. in Torr. Bot. Mex. Bound. Surv. 212 (1858); *S. calycina* var. *spongiosa*, and *S. calycina* var. *grandis* Engelm. in A. Gray, Man. Ed. 5, 493, 494 (1867); *Lophiocarpus calycinus* Micheli, in DC. Monog. Phan. **3**: 61 (1881).

Weak; leaves floating or ascending, halberd shaped, broader than long, or sagittate, hastate or entire, varying greatly, from 2 to 20 cm. long by 1.5 to 30 cm. wide, obtuse or acutish, the basal lobes widely divaricate, ovate, acuminate; scape simple, 1 to 3 dm. high, weak, at length decumbent; bracts short, orbicular, obtuse, those at the base of the staminate verticils often lanceolate, pointed; fertile pedicels greatly thickened, reflexed, as long as or much longer than the more slender sterile ones; filaments slightly roughened; achenia obovate, 2 mm. long, narrowly winged on both margins, a very short resin passage at the base of the beak above, beak about $\frac{1}{4}$ as long as the achenium, triangular, horizontal. A very variable species according to the habitat; petioles and scapes rather spongy, as are the phyllodia when present; phyllodia sometimes strongly nodose.—From New Brunswick to S. Dakota and California, and southward.

Specimens examined from New Brunswick (Fowler, Bass R., Kent Co., July, 1870); Maine (Swan, Kennebeck, Sept. 1859); Massachusetts

(Boott, Woburn Pond, 1863); New Jersey (Parker, Camden, Oct. 1877; Austin, Hackensack R., Aug. 1861); Delaware (Tatnall, Wilmington, 1861); Virginia (Coville, Colonial Beach, July 1890); Michigan (Schneck, Grand Rapids, 1880, 1881); Wisconsin (Hale, Prairie du Chien, 1861); Illinois and Missouri, many collections, 1842 to 1893; S. Dakota (Williams, 3, 5, 7 and 14, 1892); Nebraska (Williams, Greenwood, 1890); Kansas (Hitchcock, Manhattan, 1892); Indian Terr. (Palmer, 331, False Wichita R. 1868; Carleton, 268, Cherokee Outlet, 1891); Louisiana (Hale, Alexandria); Texas (Wright, 679; Oct. 1849); New Mexico (Wright, 1899, 1852); California (Parish, 1136, Los Angeles Co., Oct. 1881; Sanford, Stockton, July, 1893).

L. Guyanensis (HBK.) Micheli, Monogr. **3**: 62 (1881). *Sagittaria Guyanensis* HBK. Nov. Gen. Sp. **1**: 250 (1815).

Leaves floating, broadly ovate, deeply cordate, 3 to 5 cm. long by 4 to 6 cm. wide, obtuse to slightly emarginate; scape erect or flexuous procumbent; bracts broadly ovate, obtuse; pedicels scarcely exceeding the bracts; filaments somewhat glandular; achenia very numerous, flattened, deeply notched, winged on both margins, without resin passage, the beak scarcely surpassing the margin.— Mexico, etc., fide Micheli, *l. c.* 63.

EXPLANATION OF PLATES ILLUSTRATING THE NORTH AMERICAN SPECIES OF SAGITTARIA.

The figures were drawn, under the supervision of the author, by Miss Grace E. Johnson. Nos. 3, 28, and 29, are from living plants. No. 28 is reduced from a water color sketch drawn under Mr. J. A. Sanford's supervision by Dr. Hudson of Stockton, Cal. No. 2 is from the original plate published in the Bull. Torr. Bot. Club (1893), kindly loaned by Dr. N. L. Britton. The remainder are from herbarium specimens. Detail drawings, unless otherwise specified, are enlarged ten diameters.

Plate 1, *S. arifolia* Nutt.— 1, Plant reduced to half size; 2 and 3, lateral view and cross section of achenium; 4 stamen; 5, plant of *S. arifolia stricta*, reduced to half size.

Plate 2, *S. cuneata* Sheld.— Plant and upper portion of the scape, natural size; achenium, × 30.

Plate 3, *S. latifolia* Willd. — 1, Plant reduced one-fourth; 2, portion of a branching scape, reduced to half size; 3, 4, achenia; 5, cross-section of achenium; 6, fruiting head, natural size; 7, stamens from the same flower.

Plate 4, *S. latifolia*, Willd., forms *a* and *b*.— 1, fertile scape, reduced to half size; 2, sterile scape, reduced to half size; 3, achenium, form *a;* 4, achenium, form *b*, from Washington; 5, achenium, form *b*, from S. California; 6, achenium of *S. Sinensis* Sims, ex herb. Hooker.

Plate 5, *S. latifolia* form *c*.— 1, Plant, reduced to half size; 2, achenium; 3, cross-section of achenium; 4, seed.

Plate 6, *S. latifolia* form *d*.— 1, Plant, reduced to half size; 2, achenium; 3, seed.

Plate 7, *S. latifolia* form *e*.— 1, Plant, one-fourth natural size; 2, achenium; 3, cross-section of achenium.

Plate 8, *S. latifolia pubescens* (Muhl.).— Form *a:* 1, leaf, one-half size; 2, achenium; 3, stamen; 4, fruiting head, natural size; details after Engelmann.— Form *b:* 5, plant, three-eighths natural size. — Form *c:* 6, scape, natural size; 7, immature achenium; 8, stamen.

Plate 9, *S. Engelmanniana*. — 1, Plant, one-half size; 2, achenium; 3, cross section of achenium; 4, pistil; 5, stamen; 6, leaf, natural size.

Plate 10, *S. longirostra* (Micheli).— Details after Engelmann. 1, plant, one-third size; 2, leaf, one-half size; 3, achenium; 4, cross section of achenium; 5, immature achenium from Drummond's type collection; 6, young fruiting head, natural size; 7, pistil; 8, stamen; 9, and 10, cross sections of scape, below and above. Sketches, except no. 4, made from Canby's specimens.

Plate 11, *S. longiloba* Engelm.— 1, Plant, one-third natural size; 2, winter-tuber, with young plant; 3, achenium; 4, cross section of achenium; 5, seed; 6, stamen.

Plate 12, *S. Greggii*.— 1, Plant, one-sixth natural size; 2, leaf, one-half natural size; 3, achenium; 4, stamen.

Plate 13, *S. subulata* (L.) Buch.— 1, Plant, natural size; 2, achenium, lateral and 3, dorsal view; 4, stamen. *S. subulata gracillima* (S. Wats.).— 5, Plant, natural size; 6, inflorescence; 7, immature achenium; 8, stamen.

Plate 14, *S. subulata natans* (Michx.) — 1, Plant, one-half size; 2, achenium, lateral and 3, dorsal view; 4, stamen.

Plate 15, *S. demersa*.— 1, Plant, one-half natural size; 2, achenium; 3, stamen; 4, leaf, one-half natural size. *S. filiformis*. — 5, Plant, one-half natural size; 6, pistil; 7, stamen; 8, bracts, × 5.

Plate 16, *S. lancifolia* L.— 1, Plant, one-sixth natural size; 2, achenium. *S. lancifolia falcata* (Pursh). — 3, Part of scape, natural size; 4, achenium; 5, stamen.

Plate 17, *S. ambigua*.— 1, Plant, one-third size; 2, achenium; 3, stamen; 4, bracts, natural size.

Plate 18, *S. rigida* Pursh.— 1, Plant, one-half size; 2, 3, leaves, one-half size; 4, achenium; 5, cross section of achenium; 6, stamen.

Plate 19, *S. graminea* Michx.— 1, Plant, one-half size; 2, leaf, natural size; 3, achenium, lateral and 4, dorsal view; 5, seed; 6, stamen.

Plate 20, *S. graminea cycloptera.*— 1, Plant, one-half natural size; 2, achenium; 3, cross section of achenium; 4, stamen; 5, bracts, × 2.

Plate 21, *S. graminea Chapmani.* — 1, Plant, one-third natural size; 2, achenium; 3, stamen; 4, bracts, natural size.

Plate 22, *S. cristata* Engelm. — 1, Plant, one-third natural size; 2, achenium, lateral and 3, dorsal view, 4, cross-section; 5, stamen, ripe and 6, effete.

Plate 23, *S. macrocarpa.* — 1, Plant, one-half size; 2, achenium; 3, stamen.

Plate 24, *S. teres* S. Wats. — 1, Plant, one-half size; 2, stolon, natural size; 3, achenium, lateral view and 4, in cross section; 5, stamen.

Plate 25, *S. papillosa* Buch.— 1, Plant, one-fourth size; 2, achenium; 3, stamen; 4, bracts, × 6.

Plate 26, *S. platyphylla* (Engelm.)— 1, Plant, one-half size; 2, achenium; 3, stamen; 4, fruiting scape, one-half size; 5, 6, leaves, one-half size.

Plate 27, *S. Mexicana* Steudel.— 1, Plant, one-third natural size; 2, immature achenium; 3, stamen from bud; 4, stamen.

Plate 28, *S. Sanfordii* Greene.— 1, Plant, one-third natural size; 2, achenium; 3,stamen; 4, leaf, one-half natural size.

Plate 29, *S. Montevidensis* Cham. and Schl.— 1, Plant, one-fourth natural size; 2, achenium, lateral view and 3, cross-section; 4, stamen; 5, staminate flower, one-half natural size.

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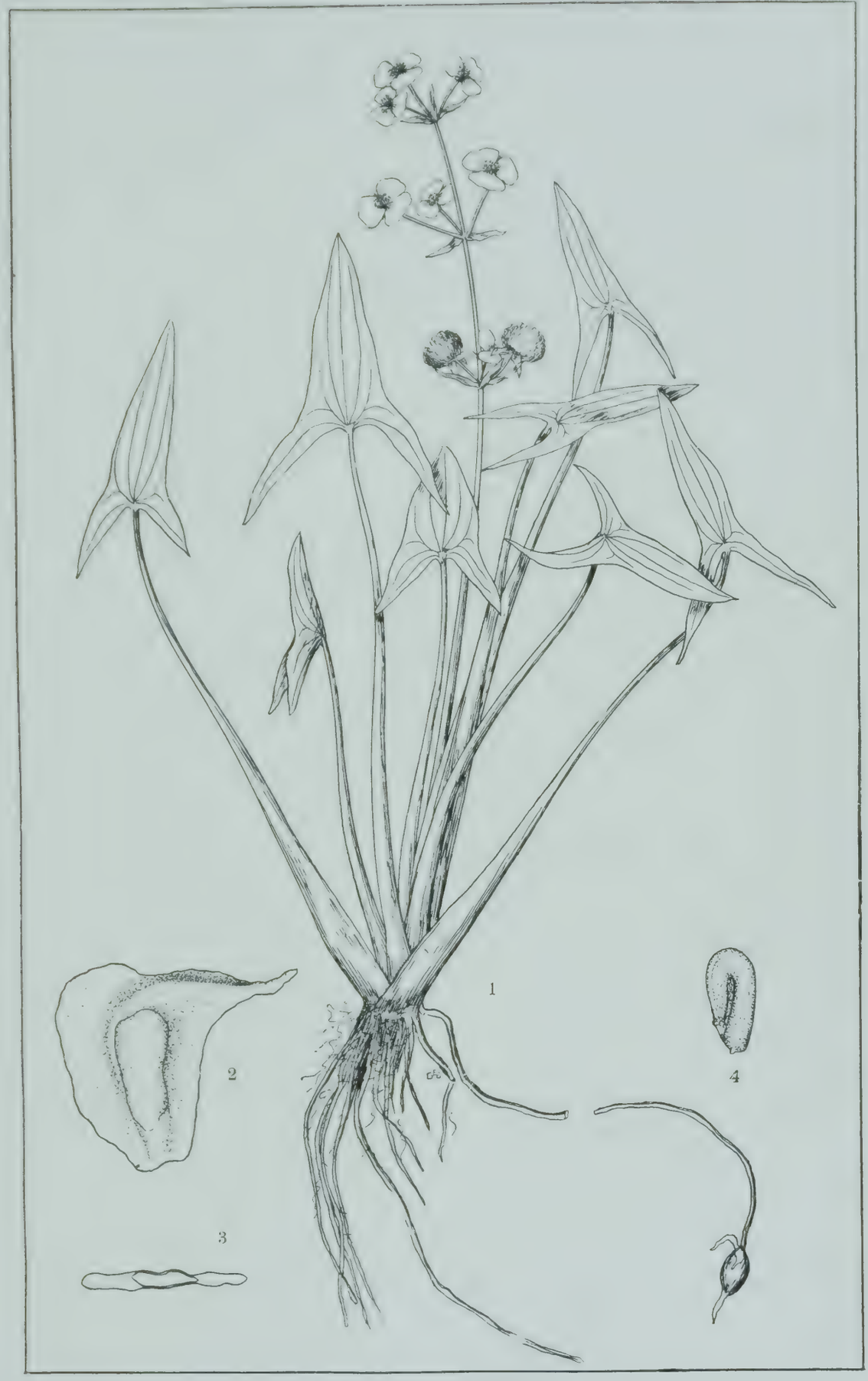
SAGITTARIA CUNEATA.

SAGITTARIA LATIFOLIA.

SAGITTARIA LATIFOLIA, *a* and *b*, and S. SINENSIS.

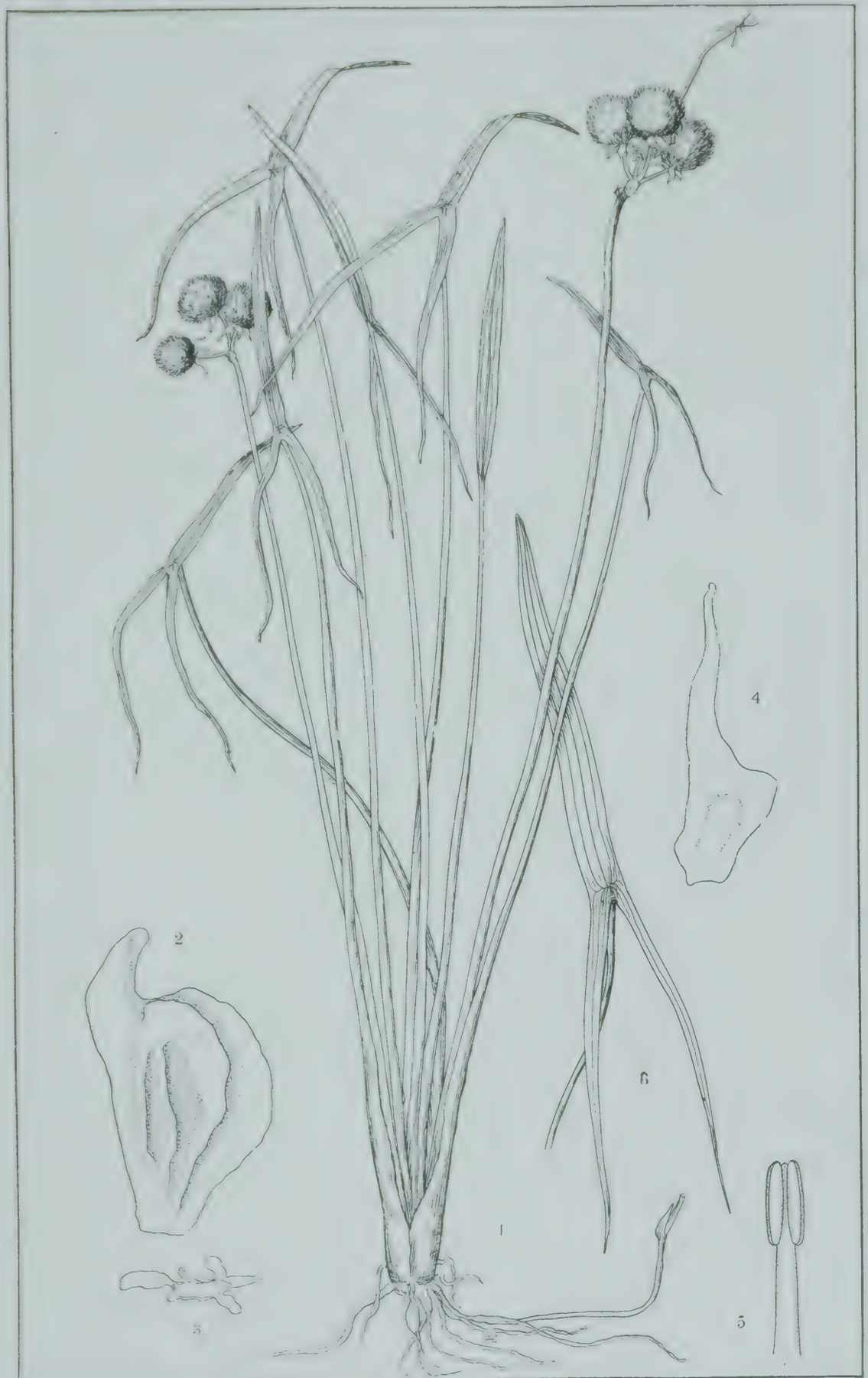


SAGITTARIA LATIFOLIA, *c.*

SAGITTARIA LATIFOLIA, *a*.

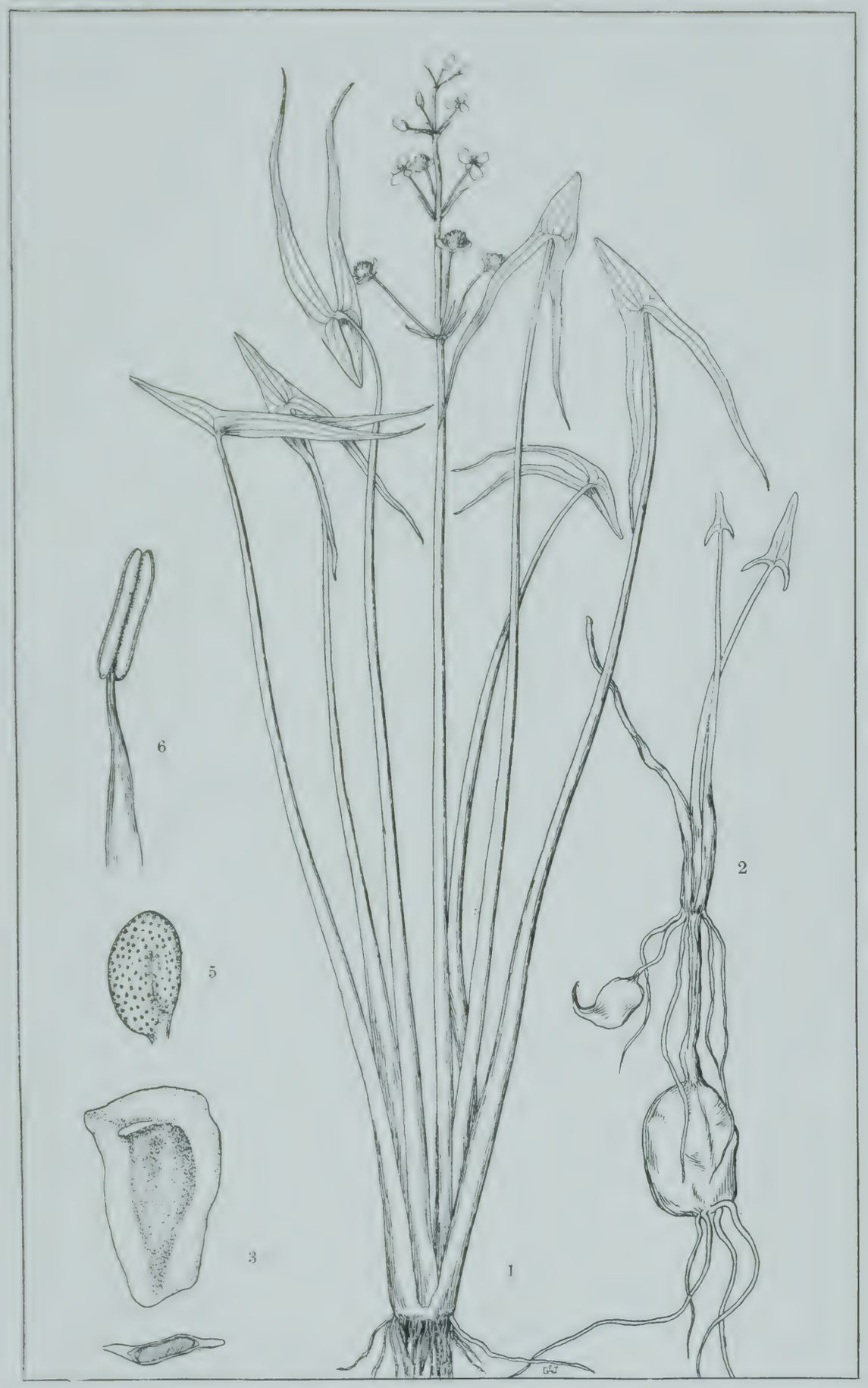
SAGITTARIA LATIFOLIA, *e.*

SAGITTARIA LATIFOLIA, PUBESCENS.



SAGITTARIA ENGELMANNIANA.

SAGITTARIA LONGIROSTRA.



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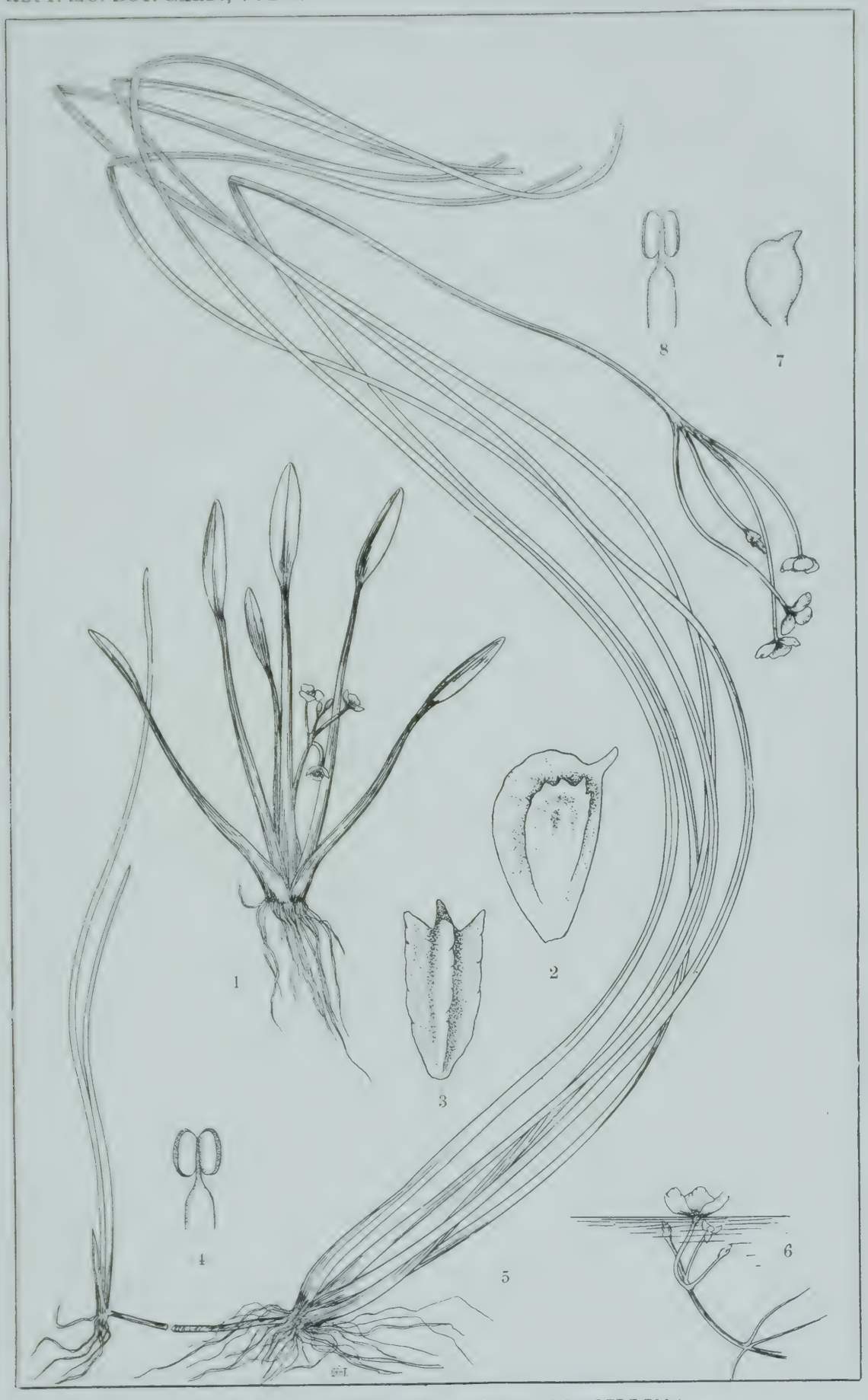

SAGITTARIA SUBULATA and var. GRACILLIMA.

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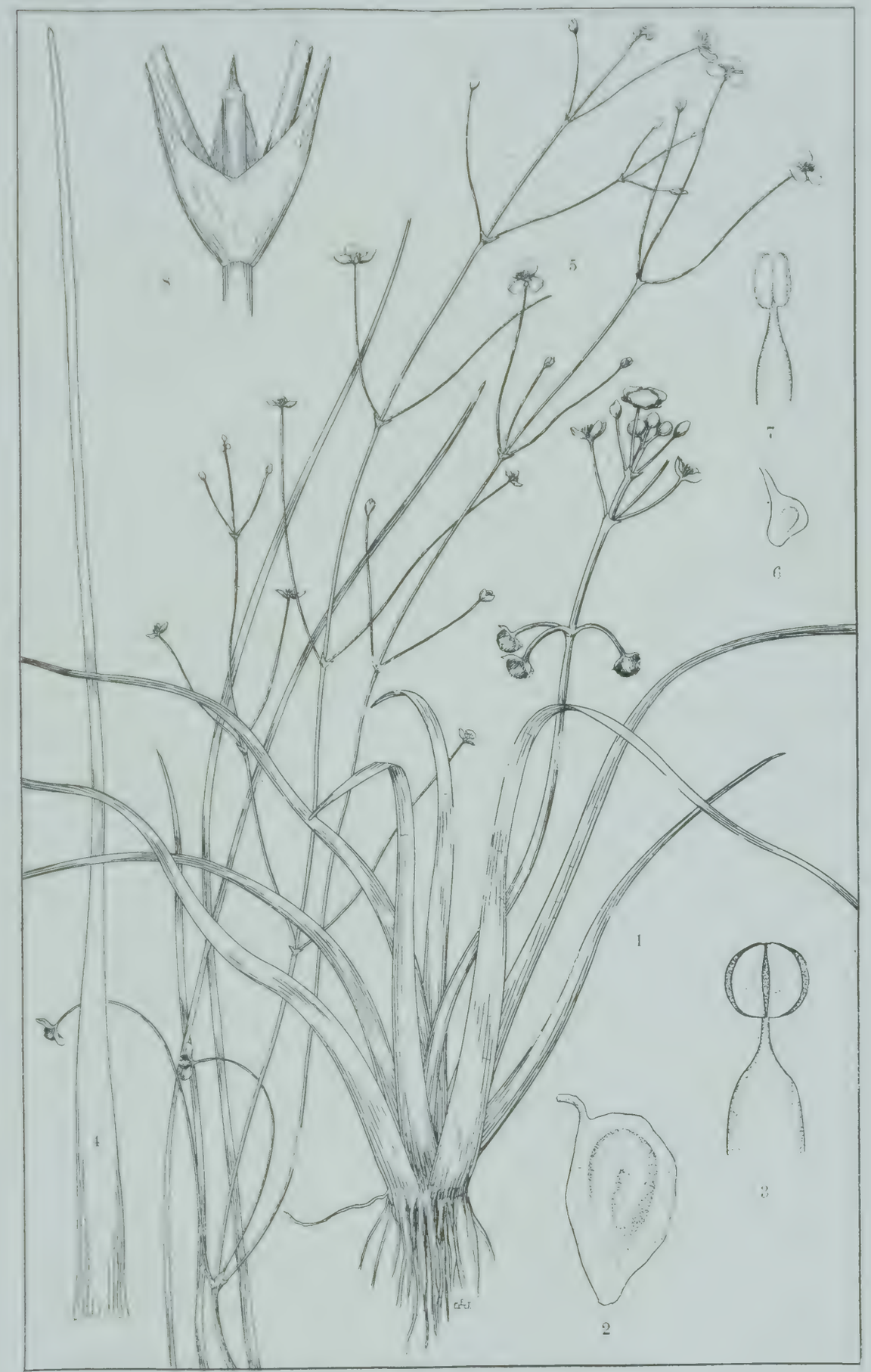
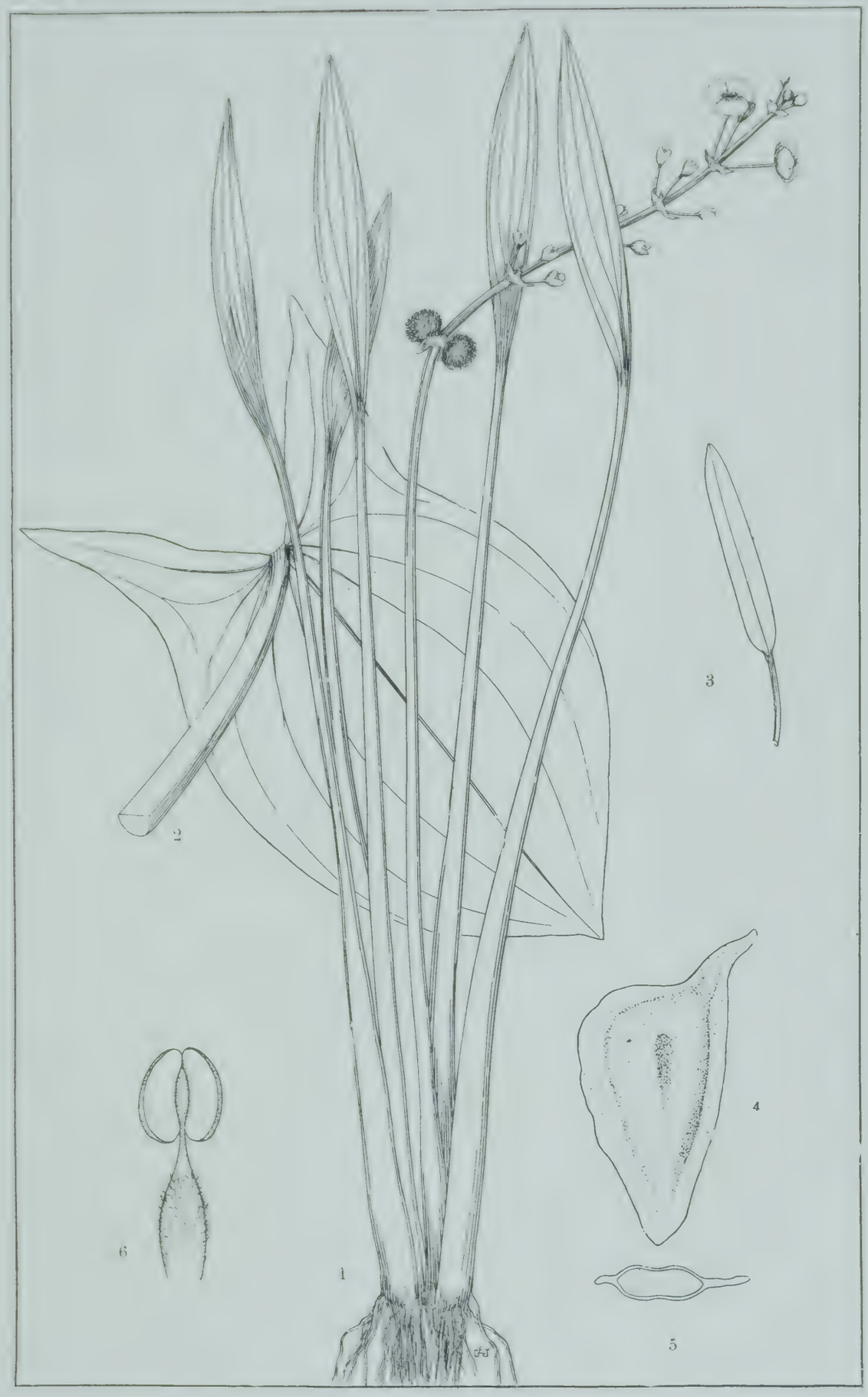


SAGITTARIA DEMERSA and S. FILIFORMIS.

SAGITTARIA LANCIFOLIA and var. FALCATA.

SAGITTARIA AMBIGUA.



SAGITTARIA RIGIDA.

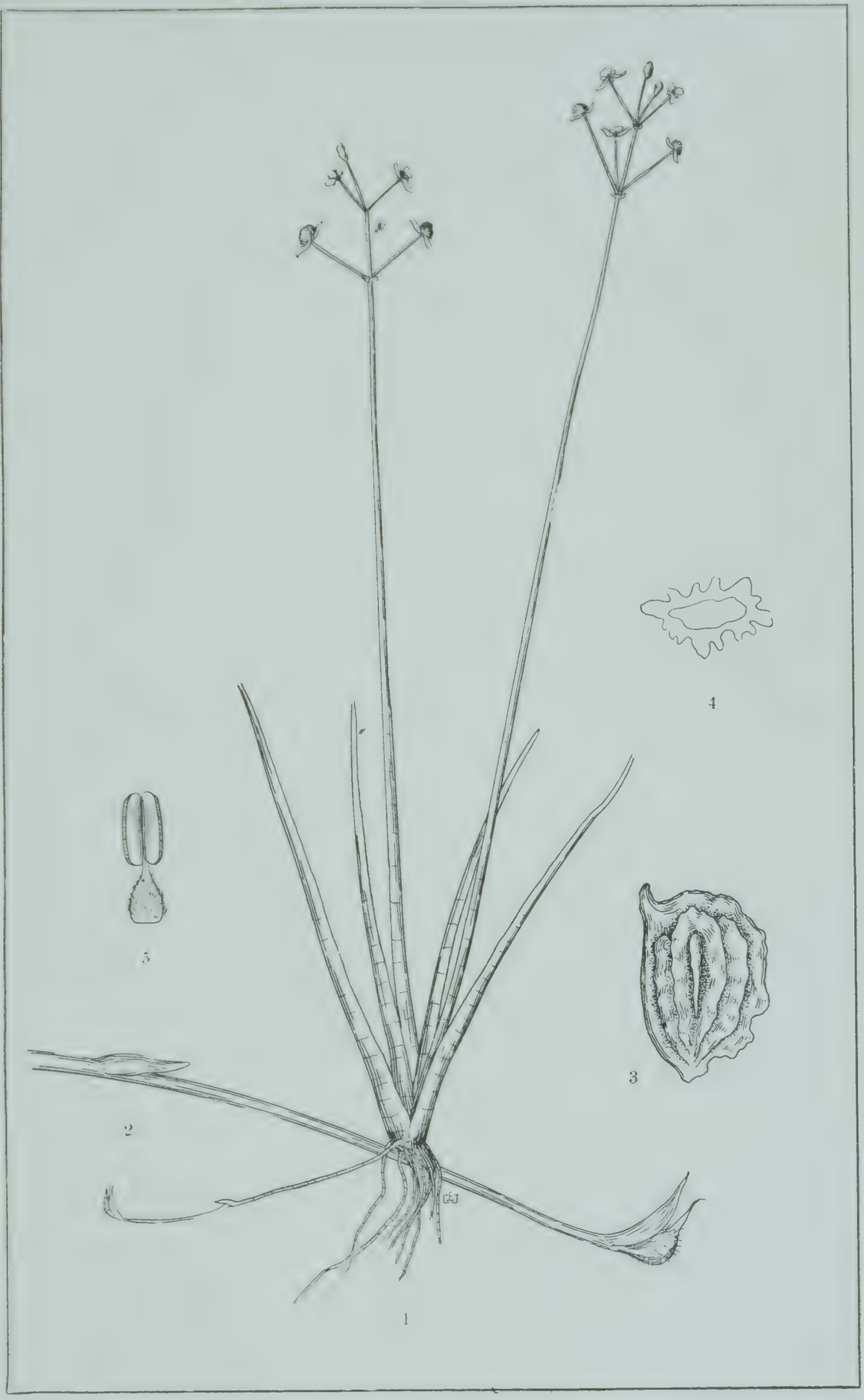
SAGITTARIA GRAMINEA.

SAGITTARIA GRAMINEA CYCLOPTERA.

SAGITTARIA GRAMINEA CHAPMANI.

SAGITTARIA CRISTATA.

SAGITTARIA MACROCARPA.



SAGITTARIA TERES.

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SAGITTARIA MEXICANA.

SAGITTARIA SANFORDII.

SAGITTARIA MONTEVIDENSIS.

LEITNERIA FLORIDANA, IN THE BOG.

LEITNERIA FLORIDANA.

BY WILLIAM TRELEASE.

While collecting in the lowlands of southeastern Missouri, in November, 1892, Mr. B. F. Bush discovered a small tree growing abundantly in the swamp, and collected specimens of the trunks, branches with staminate catkins, and a few old leaves. Notwithstanding the incompleteness of the specimens, Mr. Bush shrewdly located the plant in *Leitneria*, a monotypic genus heretofore known with certainty only from Florida; and a comparison with specimens of *L. Floridana* in the Garden herbarium, collected many years ago in Florida by Dr. Chapman and Dr. D. V. Dean, showed the correctness of the generic determination, though certain differences in minor points were noticeable. In April, 1893, he again visited the locality and collected other material in leaf and with half grown fruit; and shortly afterward Mr. Henry Eggert gathered it with nearly mature fruit.

So far as we now know, the tree occurs in the deep swamps of Butler and Dunklin counties, where it is associated with plants of distinctly southern range, such as *Taxodium distichum*, *Acer rubrum Drummondii*, *Nyssa uniflora*, *Planera aquatica*, and *Polygonum densiflorum*. As I have convinced myself by personal observation at Kennett and Neelyville, it grows in rich swamp soil in sloughs and similar places, which never become dry and where there is usually from six inches to two or three feet of water; and Mr. Bush states that along the St. Francis River it is most frequent in water from three to five feet deep, where it is rooted in the basal mass of *Polygonum densiflorum*, the common swamp smartweed of that region, which occurs in dense growths often forming a floating

accumulation on which in places a man may walk. Certain of these sloughs are almost exclusively occupied by the *Leitneria*, which has a spreading root system confined to the surface layers of the soil. Apparently suckers arise from some of the roots, as is the case with the Ailanthus and White Poplar, but I have not been able to actually trace these young shoots to the older plants, though their root system is usually developed out of proportion to their size.* The impression made on one by such a Leitneria swamp is that of a tangle of coarse bushes from five to ten feet in height, but on closer observation it is evident that each stem rises separately from the soil or water, so that the plant lacks the clustered bushy habit which distinguishes a shrub from a small tree, and it not infrequently attains a height of fifteen to twenty feet and forms a trunk from three to five inches thick toward the base, where it gradually increases in thickness as do many other swamp trees.

Such arborescent specimens have a clear cut trunk below and are loosely branched above, with the ascending ultimate twigs commonly as thick as a lead pencil. Its bark is gray below and rather smooth, usually mossgrown where wet. The twigs incline to brown, or in the case of suckers are almost orange colored, and are marked by numerous slightly prominent lenticels usually of a lighter gray. During the first year they are densely pubescent with ascending dingy hairs, some of which persist during the second year, but ultimately they become glabrous. The leaf scars are five-ranked, rather uniformly distributed along the twig, slightly elevated, and of a general crescent form with obtuse angles and a not infrequent trilobation. Each contains three relatively large bundle scars. No stipule scars are to be seen.

The small persistent terminal bud is broadly conical and

* Apparently connected with this mode of spreading, is the preponderance of one sex in each swamp; a fact which Dr. Dean also informs me he has observed in Florida.

protected by about a dozen obtusely triangular gray-tomentose scales, which evidently represent undeveloped leaves and some of which usually persist for a year or two at the annual nodes, ultimately leaving rings of narrow transverse scars marking the site of former winter buds. On mature plants the upper axillary buds are generally flower buds, and develop in the autumn into oblong erect subsessile hairy catkins about half an inch long, surrounded at base by the bud scales, which pass into the very acute scales of the inflorescence. The trees are dioecious, and while the catkin character of the flower shoots is very evident on the staminate trees, it is much less noticeable on pistillate trees, the catkins of which are not above half the thickness of the others, and with correspondingly narrower scales. The lateral leaf buds are half ovoid, small, appressed to the stem, and protected by a few scales similar to those of the terminal bud. So far as has been observed, no supernumerary buds, either collateral or superposed, occur.

The leaves are lanceolate to elliptical lanceolate, acute at each end, entire, very narrowly revolute, 3 to 4 inches long, on half-round petioles about 1 in. long, and densely appressed villous, with a few interspersed clavate glandular hairs, especially on the petiole, and evident only on close inspection. With age they may become as much as 3 × 7 in. with petioles 2 to 3 in. long, and are then glabrate and somewhat glossy above except along the midrib and principal veins, thick and of coriaceous texture, and finally very rugose on the paler under surface from the prominence of even the finer veins. Stipules have not been seen.*

The flowers expand before the leaves, early in March, when *Acer rubrum Drummondii* is in bloom. The stam-

* In *Leitneria Floridana* stipules are said to occur by Baillon, Hist. des Plantes, vi. 241; Van Tieghem & Lecomte, Bull. Soc. Bot. de France, xxxiii. 184; and Heim, Recherches sur les Diptérocarpacées, — Thesis, Paris, 1892, — 176. They are not found by Chapman, Fl. So. U. S. 428; Oliver, Hooker's Icones Plant. ser. 3, i. pl. 1044; and Bentham & Hooker, Genera Plantarum, iii. 397.

inate catkins then become from one to two inches long, generally curved outwards, and their scales spread just enough to expose the stamens and allow the very abundant and powdery yellow pollen to escape. The soft parenchyma of the axis of inflorescence becomes torn in various directions as the catkins elongate, so that when they have reached their full development it is loosely fissured throughout. The fibrovascular bundles at the same time are poorly developed and almost unlignified, so that it is almost impossible to dissect a catkin without tearing it in pieces. The same loose texture exists in the basal part of the catkin scales, where they have increased in length during anthesis, and as the outer part is considerably longer than the inner, it assumes a series of characteristic transverse wrinkles below. This separation of the tissues in both axis and bract, gives rise to the curious appearance in longitudinal section which is shown in plate 32, fig. 4–5, for the cleft in each bract is decurrent down the axis to the point where the firmer fibrovascular bundles emerge for the next flower. The staminate flowers, so far as I have examined them, are glabrous and quite destitute of a perianth or involucre of any description, and consist simply of a whorl of about ten short filaments a little dilated at base and surmounted by slightly versatile but nearly erect extrorse two-celled anthers dehiscing longitudinally. The pollen grains are nearly globose, smooth, slightly 3 to 4-grooved with underlying thickening of the intine, and fall from the dehiscent anther very readily, and there is no doubt that the species is wind pollinated.*

The pistillate catkins possess the same loose lacunose structure as the staminate, though the axis is far less torn. When fully developed they are rarely over half an inch long, and it requires some little care to detect their presence on

* The structure of the staminate flowers, aside from the lacunose character of the axis and bract, and the extrorse facing of the anthers, is well shown by Baillon, *l. c.* 240, f. 214; Oliver, *l. c.* f. 1 to 3; and Heim, *l. c.* pl. 10, f. 1 to 6. Baillon, *l. c.* 239, mentions bractlets as being sometimes present.

the trees, whereas the staminate catkins are very evident from a considerable distance. Unlike the staminate flowers, the pistillate, which are limited to the upper axils, are very short-stalked or with a rudimentary disk, and possess a rudimentary involucre or perianth of a few small, glandular-fringed scales, the largest two of which stand nearly laterally while the remainder are dispersed along the side next the axis of the catkin.* Only one carpel is present. The ovary is shortly ovoid, finely pubescent, one-celled, and contains a single ascending parietal ovule with the micropyle directed upwards. The green or slightly reddish style is attached a little at one side and in anthesis curves outwards and becomes grooved on the stigmatic side, or somewhat flattened, with the stigmatic surface undulated, possessing the general characters of wind-pollinated stigmas. The placenta and stigmatic groove are turned away from the axis and face the bract, a very unusual position for the suture in a monocarpellary flower, and one which appears to indicate that the flower is in reality reduced from a former state in which there were two carpels radially arranged with reference to the bract, or perhaps a larger number; and this inference that the simple flower of *Leitnera* has been formed by the reduction of an originally more complex flower is further supported by the presence of a rudimentary perianth about the pistil, and by the reported occurrence of abortive pistils near the end of the staminate catkins in some instances,† and of one or more stamens within the scales of occasional pistillate flowers.‡

The fruit is an erect compressed dry drupe measuring

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* Eichler (Blüthendiagramme, ii. 42) calls attention to the large size of the lateral scales, which, from analogy with *Myrica*, he regards as bractlets, considering the others as a perigone, and Van Tighem & Lecomte (*l. c.* 184) recognize a calyx as present in the pistillate flower. Heim (Ass. Franç. *l. c.* 231) on the other hand speaks of the absence of both calyx and corolla, in agreement with Baillon, who speaks of the whorl of scales as a false calyx (*l. c.* 240, note).

† Oliver, Hooker's Icones, *l. c.* p. 34.

‡ Baillon, Hist. vi. 240, note.

about 6×8×22 mm. in the Floridan specimens, though in the few Missouri specimens that I have seen it was of scarcely more than half this size. Its surface is coarsely rugose-reticulated over the firm fibrovascular bundles of the pericarp. Near the top it is marked by an oblique scar left by the caducous style, and it contains a single large seed with a straight embryo and a rather thin layer of albumen.*

So far as can be made out at present, the Missouri *Leitneria* differs from that of Florida only in its larger size,— the southern plant being described as a shrub 2 to 6 feet high,— in its somewhat larger more coriaceous leaves rarely more than acute at apex, while those of the Floridan plant are usually somewhat acuminate, and in its apparently smaller fruit. Neither of these characters, however, need of necessity be of specific value, nor represent more than individual variation due to habitat, climate, or age.

In an account accompanying his illustrations of *Leitneria Floridana*, Professor Oliver † mentions "specimens of perhaps a second species of *Leitneria* from Texas, collected by Drummond;" and Bentham and Hooker ‡ and Hemsley § admit this probable second species. In reply to an inquiry, Professor Oliver writes me that the material of this form consists of imperfect specimens without original label but labeled by Sir William Hooker as from "Rio Brazos, Texas, Drummond;" and he adds that so far as these specimens go, he does not now see any reason why they should not belong to *L. Floridana*, though the catkins are

* Except for the extrorse placental suture, and the lacunose bracts and axis, the structure of the pistillate flowers is well shown by Baillon, f. 215; Heim, pl. 10, f. 7 to 10; and Oliver, f. 6 to 8 — where the position of the stigmatic groove is correctly shown, but the placenta inverted. The fruit and seed characters are also shown by Baillon, f. 216; Heim, pl. 10, f. 11 to 22; and Oliver, f. 9.

† Hooker's Icones Plantarum, 3 ser. i. p. 34.

‡ Genera Plant. iii. 397.

§ Biol. Centr. Amer., Bot. iii. 162, iv. 193.

perhaps slenderer. In a letter accompanying this note, Mr. Hemsley states that he also suspects that all of the *Leitneria* material is of one species.

Dr. Chapman informs me that in Florida the original stations of the species on the coast have long since been washed away, but he afterwards found it inland, where, nevertheless, its distribution is not known to be more than very restricted. Whether the Texan material referred to above was actually gathered along the Brazos, or possibly further east, where Drummond also collected extensively, the occurrence of *Leitneria* in Missouri is, therefore, very remarkable. But the investigations of Mr. Bush have shown that this part of our State is a meeting-point for the floras of the Middle States, the eastern Gulf region and Texas.*

The reason for the extension of the Gulf Flora noted, appears to lie in the deep swampy character of much of the land along the general course of the Mississippi River in southern Missouri and northern Arkansas as well as further toward the Gulf. This entire region is noted for the present fluctuations in its water level, due to artificial elevation of the immediate bounds of the great river and its tributaries, some of which nevertheless are destroyed almost every year during freshets; but presumable natural changes, and the large measure of success which has been reached in confining the streams to their channels and inducing a more rapid flow near the mouth of the Mississippi, have resulted in lowering the maximum average level of the water in case of inundation, and a far more perfect drainage of the lowlands than formerly, during the season of low water. This seems to be indicated quite clearly by a study of the cypress trees of the region. I believe it is generally admitted that the level to which the root knees of the cypress rise in wet cypress swamps corresponds closely with the normal flood water level. This is

* Fifth Garden Report, 140.

the case in the deep sloughs of the Varner and St. Francis rivers near Kennett, though at low water the knees emerge about two feet. But here and there dead knees, quite unconnected with standing trunks, or clearly belonging to the shells of old trees none of which are now living, rise some three feet beyond the level marked by the knees of existing trees. These vestiges of an earlier forest growth appear to indicate that when they were in their prime the water level stood several feet above the present flood level, and so far as can be estimated from the trees this was somewhere from two hundred to five hundred years ago.

Professor R. Ellsworth Call, who has made a geological study of the region in which these plants now appear to find their northernmost home, writes me that the Mississippi river formerly without question flowed far to the west of its course to-day, and in comparatively recent geologic times cut away the opposing ridge below Cape Girardeau, and excavated its present channel and the lowlands around. Meantime it has swung across the valley several times, but its westward movement has been successfully resisted by the remains of the great Tertiary plateau or northward deposit of the ancient Gulf, which extends from Florida to Mexico and northwards to this region, of which Crowley's Ridge is believed to be the last remaining vestige in the middle valley. He mentions as interesting in connection with these changes in the Mississippi and its immediate valley, the fact that the Ohio long preserved its integrity to a point not far from the present site of Helena. He also states that there can be no question that these changes at times have been retarded by depression of the whole area, and at times hastened by elevation; that there have been comparatively recent times when all the region about northeast Arkansas and southeast Missouri was a veritable marshy waste; and that this condition has been several times repeated, with a synchronous ameliora-

tion of climate favoring the northward extension of a subtropical flora over the region.*

It seems probable, therefore, that *Leitneria* and the species of the Floridan flora which accompany it in the Missouri swamps, represent the remnants of a warm temperate swamp flora which at one time extended continuously in the low lands, around the coast and up the river, from Florida to the upper limits of the present deep swamps; and that they are now likely to be found in such situations at any point between the extremes, where the original conditions have remained little or not at all changed by the general drainage which has been progressing at least for the last few centuries. One of the most promising fields for botanical exploration in the eastern United States, and one of the least known, is the swamp region of the lower Mississippi Valley and the Gulf Coast; and I have little doubt that a fuller knowledge of the flora of this region will not only confirm the explanation here offered of the occurence of *Leitneria* in Missouri, but extend its known range from this point to its original locality in Florida. Unless there is an error in the label of Drummond's specimen, it should also be found in similar situations across Louisiana and around the Gulf in Texas.

Mr. Bush's attention was first called to the occurrence of *Leitneria* in Missouri by the frequent mention in the swamps of a very light "cork wood," greatly surpassing even young tupelo (*Nyssa*) in buoyancy, and much used by fishermen for floats on their nets; and the trunks which he placed in my hands were of such surprising lightness that I requested my friend Professor Nipher to determine the specific gravity of the decorticated wood. An exam-

* The results of Professor Call's work, here briefly outlined from his letter, are to be found in the Proceedings of the Iowa Academy of Science, 1887–9, 52, 85, and more fully, as volume ii. for 1889 of the Reports on the Arkansas Geological Survey. See, further, a paper by him in Amer. Journ. Sci. and Arts, 1891, xlii. 394, on the fossil woods of this region, also considered in his larger report.

ination by his assistant, Mr. Brogan, shows it to possess a density of 0.207, water being taken as unity.* As is often the case with the roots of light trees, those of this species are appreciably lighter than the stem, and a similar determination made by Mr. Timmerman at the request of Professor Nipher, gives for its root wood a density of 0.151, though as a cylinder of 3.79 cc. only could be used, it is probable that this determination is less accurate than that for the trunk.

In his treatise on the forest trees of the United States,† Professor Sargent gives a tabulation of the specific gravity of the woods of all the North American trees recognized at that time, as determined at the Watertown Arsenal. From his tables it appears that the lightest known native wood (that of *Ficus aurea* of Florida), has a density of 0.2616, and the heaviest (also a Floridan species, *Condalia ferrea*), has a specific gravity of 1.302, while the density of the great majority of species lies between 0.400 and 0.800.‡

From a set of tables based on the experiments of Captain Fowke,§ on the woods exhibited at the Paris Exposition of 1855, and the London Exposition of 1867, it appears that an East Indian wood, "Dedoaf Tha," has a specific gravity of 0.260, very nearly that of *Ficus aurea*

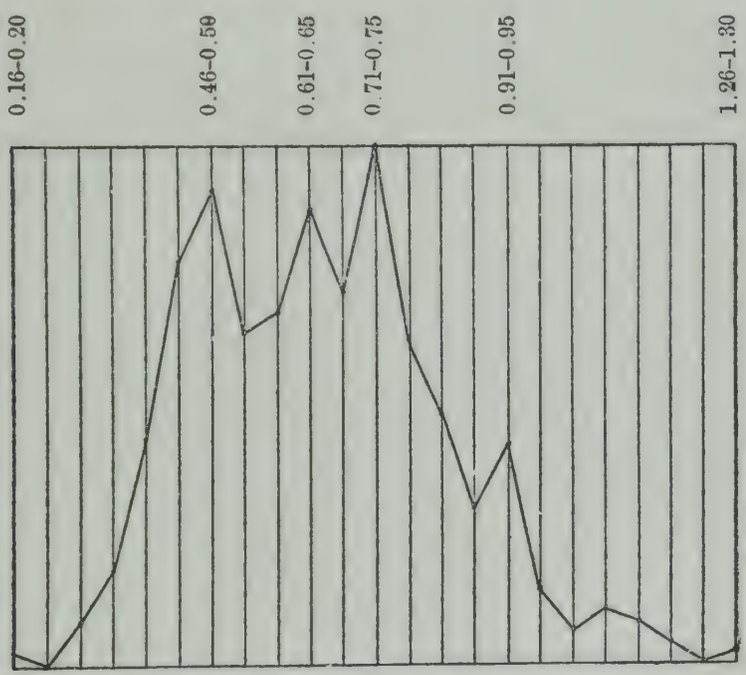
* Professor Nipher informs me that in the determination, a cylinder was used, turned as accurately as possible, which was measured at a sufficient number of points to give average values, and the density was obtained by calculation from the dry weight of the cylinder, correction being made for absorption of water between the time of removal from the drying bath and the completion of the weighing, it having been found that the gain from the atmosphere was .007 gr. per minute, for the cylinder used.

† Final Rept. Tenth Census, ix. 249.

‡ As a few examples may be mentioned the common hickories, ranging from 0.810 to 0.837, white oak, 0.747, tupelo, 0.519, the willows and poplars, usually considered very light woods, and lying between 0.363 and 0.607, and white cedar, a favorite material for light boat construction, with a density of 0.332.

§ Science and Art Department of the Committee of Council on Education, London, printed by George E. Eyre and William Spottiswoode, 1867, p. 10.

as given in the census tables. *Ochroma lagopus*, one of a number of so-called cork woods enumerated by Wiesner,* is said to have a density of 0.250,† but I cannot place my hand on any determinations lower than this. Professor Nipher tells me that the specific gravity of common cork (the bark of *Quercus Suber*) is given by Ganot as 0.240. Although individual variability and the difficulties of determining the specific gravity of porous and absorbent bodies like wood make it unwise to accept any of these figures as invariable, it appears from them that the wood of *Leitneria* is very markedly lighter than the bark of the cork oak, which itself is considerably lighter than any other wood of which a record can be found.



FREQUENCY OF TIMBER DENSITIES.

The appended curve, compiled from the census tables, shows the relative frequency of occurrence of the different degrees of density in our native timbers, each co-ordinate representing a difference of .050, and each species falling within this range being represented by a vertical distance of

* Rohstoffe, 578.

† Goodale, Physiological Botany, 145.

1 mm. on the co-ordinate. Thus, one species has a specific gravity between 0.16 and 0.20 inclusive; none occur between 0.21 and 0.25; 46 are found between 0.46 and 0.50; and 50 lie between 0.71 and 0.75. The majority of species (242) occur between the maximal points of 0.46 and 0.75, and it is evident that the fall is much more abrupt from these common densities to the lowest recorded density than to the highest, so that any extension in this direction is more remarkable than a corresponding one in the other.

As the density of wood freed from resin etc., air and water, is about one-half greater than that of water, the reason for the extreme lightness of the wood of *Leitneria* is to be looked for in connection with its loose structure, the softness of its tissues, which are easily compressible under the thumb nail, and the absence, at least in the largest specimens I have seen, of any heart wood, the texture being homogeneous throughout.* It was, therefore, subjected to a rather careful microscopical examination, with the following results.†

The pith is nearly round in cross section, although where the bundles of the primary wood join it they project slightly, giving it a minutely crenulate outline. It is continuous and of uniform texture, thus differing from the pith of plants like *Paulownia* and *Lonicera* which are excavated, or *Juglans*, which is chambered,‡ and from that of *Liriodendron*, etc., which, though solid, is traversed by firmer transverse plates. The cells, as is usual in pith, are approximately isodiametric and polygonal, as seen in cross section, a little smaller near the periphery; and in longi-

* On this general subject see Nördlinger, Gewerblichen Eigenschaften der Hölzer, Stuttgart, 1890, 17; and Techn. Eigenschaften der Hölzer, Stuttgart, 1860, 115.

† The substance of this paper was presented orally before the Academy of Science of St. Louis on May first, 1893, and illustrated by specimens of the plant and photomicrographs, some of which are here reproduced in half tone or are made the basis of line engravings, showing the structure of the wood and bark.

‡ The "discoid pith" of Morren, in Ann. of Nat. Hist. 1839, iv. 73.

tudinal section they often appear as rectangles, with their greatest diameter transverse. Their walls, which are very thin, show, nevertheless, a decided secondary thickening, and are marked by simple pits, as is usual in pith of this description. Toward the wood, and especially where the pith rays pass outward to the branches, occasional cells in more or less marked vertical rows occur, with large stellate crystals.

At the margin of the pith a number of layers of cells of reduced diameter but several times as long as the pith cells, constitute a pith sheath, and gradually merge into what are virtually wood parenchyma cells. They have the same simple pits as the pith cells, but are arranged in vertical rows in relation with the elements of the xylem, and vary in length from twice to four or five times their diameter. In the mass of parenchyma so formed at the margin of the pith, are found intercellular secretion reservoirs, each of which is surrounded by a layer of oblong secreting cells with walls not appreciably thinner than those of the parenchyma immediately about them. From one to two dozen such passages are to be seen in a cross section of the stem.* Though as a rule they occur singly, it is not uncommon for two of equal size to stand close together, separated by only a few layers of cells, or for small ones to stand on one or both sides of a larger one. The secreting cells are usually

* These were formerly attributed by Van Tieghem (Ann. des Sci. Nat. 7 ser. i. 64, and Van Tieghem and Lecomte, Bull. Soc. Bot. de France, 1886, xxxiii. 182) to the apexes of the primary xylem wedges, but, accepting as the inner limit of the wood, the position of the innermost vessels, Professor Van Tieghem now recognizes these secretion passages as pertaining to the pith (Morot's Journal de Botanique, v. 384, 385), thus coming into agreement with Müller (Engler's Bot. Jahrbücher, ii. 449), Burck (Ann. Jard. Bot. Buitenzorg, vi. 151), and Heim (Ass. Franç. p. l'Avanc. des Sciences, 1891, i. 231; Rech. s. les Diptérocarpacées, Thesis, 1892, 175), who have attributed the similarly situated passages of Dipterocarpeae to the pith. But Reinsch, Engler's Jahrb. xi. 374, speaking of the Balsamifluae, again calls attention to their close connection with the xylem, and, indeed, it appears extremely difficult so to define the hadrom bundle as unequivocally to separate it from the adjacent pith.

quite convex on the free side, and sometimes protrude into the passage as papillae or in balloon-like outgrowths. Their secretion is a yellowish resin, which fills the passages in sections cut dry and examined in water, but rapidly dissolves when this is replaced by alcohol drawn in at one side of the cover glass, leaving a residue of fine emulsion drops similar to those formed when an imperfectly anhydrated preparation is mounted in Canada balsam. In sections examined in water after being cut dry, the contents of the secretion passages are traversed by fractures, sometimes regularly curved, and their high refractive power gives rise to the appearance of a limiting membrane about the individual masses, suggestive of a raised cuticule of the secreting cells, beneath which, according to Tschirch,* the formation of the resins of schizogene passages occurs. In observing the solution of the resin on the addition of alcohol, however, the apparent membranes are seen to completely disappear at once, and I have not been able to detect either cuticular blisters or vestiges of the bases of such blisters in these sections after the solution of the resin, nor in any of the numerous sections of alcoholic material which I have examined.†

Just outwards from the situation of this ring of secretion passages, each wedge of the hadrom or xylem begins with

* Berichte Deutsch. Bot. Ges. xi. 201, and Pringsheim's Jahrb. xxv. 375.

† Some difference of opinion exists as to the nature of the secretion within these passages. Van Tieghem and Lecomte (*l. c.* 182) speak of it as a resin, while Heim (Thesis, 176) calls it a balsam. The entire group of terpenes, ethereal oils, resins, and balsams, is a difficult one chemically, and I do not venture to pronounce on the one now in question further than to say that it is insoluble in water, soluble in cold alcohol except for the emulsion residue referred to above, and that Mr. Bay, who at my request tested it with the Unverdorben-Franchimont reaction to acetate of copper (Poulsen, Mikrochemie, 73; Zimmermann, Bot. Mikrotechnik, 89), found that it assumes with this reagent the green color characteristic of resins and terpenes. It may be noted that the same reagent gives an abundant brown precipitate throughout the bark, indicative of the presence of tannin. On the resins see further Tschirch, Pringsheim's Jahrb. xxv. 370.

a few tracheides and spiral vessels about 20 μ in diameter, surrounded by wood parenchyma. Aside from this, except where the bundles pass out to the leaves, no true spirals occur in the stem. The remainder of the xylem consists of pitted tracheides and ducts, wood parenchyma, and, chiefly, libriform cells. Except for the spiral vessels mentioned above, the vascular elements of the wood are all furnished with bordered pits, a scalariform reticulation marking their contact with the medullary rays.

The pitted vessels are distributed through the stem in a characteristic way, as is usual in woody plants. Each year's growth in the secondary wood begins with a greatly interrupted row of vessels large for the plant, and measuring from 50 to 95 μ in diameter. In addition to these vernal ducts, each year's zone of wood contains a number of groups of similar but smaller vessels, which are arranged either approximately parallel to the circumference or with an oblique direction outwards, often strongly accentuated in the older wood where it may become quite radial, and, as a common thing, grading in size from the middle to each extremity or from one end to the other, most diameter measurements lying between 25 and 35 μ. These groups consist of the elements usual in such duct accumulations, namely vessels, tracheides, and wood parenchyma. The vessels show a complete disappearance of the cross septa which originally divided the vertical rows of rather short cells from which they arise, except for a narrow ring around the margin, in this respect differing very markedly from the similar vessels of *Liriodendron*, *Liquidambar*, etc., where the perforations are formed in such a way as to leave the original septum as a persistent scalariform plate running obliquely across the mature duct.

The wood parenchyma, which is not abundant, and stands in close connection with the ducts and annual rings, does not differ particularly from the parenchyma already described about the secretion passages in the pith sheath. The tracheides as a rule are similar to the libriform or common wood

cells, presently to be described, except that their walls are somewhat thicker,—sometimes much thicker,—and marked, even on the tangential sides, with bordered pits very different from the simple pits of the libriform cells and parenchyma. Their walls not infrequently show a spiral striation which in its most marked form consists in a fine acute spiral ridging of the inner surface of the cell, the ridges, however, differing from those of the spiral vessels in being wedge shaped with a broad base, whereas in the vessels they are of a generally round section, and attached by a narrow base, which is easily broken, so that they can be uncoiled from within the lumen.

Except for these masses of vessels with their accompaniment, and a layer of cells presently to be described, at the limits of each year's growth, the wood consists of libriform or ordinary wood cells, which differ from the tracheides in possessing on the radial walls very small, obliquely crossing, not evidently bordered pits, scattered or irregularly grouped. They are fusiform or, more accurately, obliquely truncated at the ends, which overlap in such a way as to be very evident in tangential sections while much less obvious in radial sections. Their length is usually fifteen to twenty times their diameter, the measurements as a rule lying between 15×275 and $20\times375\,\mu$. Now and then these libriform cells are found with transverse partitions running directly across, one or two to each cell, a condition that has been observed frequently in other woods. While striation is much less evident than in some of the tracheides, it is sometimes to be seen.

Rings indicative of the annual (or more accurately periodic) growth in thickness of the stem, though nearly invisible to the naked eye, are evident on an examination of the wood under a lens, being partly caused by the occurrence of a broken row of vernal ducts, and in part by a gradual reduction in the radial diameter of a few rows of libriform cells formed toward the end of the growing season, whereas those first formed the next spring are of

ample size. The most striking feature of these annual rings, however, consists in the production of a row of parenchyma cells replacing the libriform as the first series cut off by the cambium each spring at the beginning of the year's growth. These cells are about ten times as long as broad, with horizontal septa, some of which are evident in all cross and radial sections of the wood, and, like other cells of the wood parenchyma, they show simple pits similar to those of the medullary rays. Exceptionally this annual layer of parenchyma is locally doubled by tangential division.

Between the xylem wedges occur the usual medullary rays. So far as I have seen, these rays, except where they stand in connection with pith rays, are not more than two cells in thickness, and it is extremely unusual to discover more than a single row of cells in their cross or tangential section. As seen in longitudinal section, they consist of from one to about twenty vertical series of cells, most commonly about ten. These cells usually measure 18 to 25 μ in height, 7 to 10 μ in width, and 40 to 75 μ (as a general thing) to above 100 μ in radial length. Their vertical septa frequently are somewhat oblique when viewed in either transverse or radial section. Their walls are thin, and simply pitted to correspond with abutting cells.

All of the elements of the xylem show the customary middle lamella, with a secondary thickening, which, however, is very slight, so that the walls of the libriform cells are rarely over 1.5 μ thick, while the medullary ray cells are thinner, and the tracheides and the wood parenchyma cells generally range respectively a little thicker and a little thinner than the libriform, the vessels being, in fact, the only thick walled cells of the wood, except for occasional groups of exceptionally thickened tracheides.

From its gross anatomical characters, the wood of *Leitneria* would be compared with Hartig's group of dicotyledonous woods having all of the ducts small, those of the

spring growth neither large nor numerous, and the medullary rays invisible to the naked eye.* The occurrence of a single broken row of vernal ducts somewhat larger than those of the rest of the year's growth, the oblique position of the groups of the latter, and the absence of loose parenchymatous bands, suggest a comparison with *Aster argophyllus*, certain species of *Ulmus* and *Celtis*, and, particularly, *Daphne Mezereum*.† Except for the absence of coarse parenchyma bands, it also resembles somewhat the wood of *Ailanthus*, *Hippophae*, and numerous Leguminosae, though in these the vernal ducts are usually larger and more numerous, and the secondary thickening of the medullary rays and the libriform cells is far more marked.

The cortex of *Leitneria*, which, as has been stated above, is rich in tannin, is rather thin, and consists at first of fundamental parenchyma, which is collenchymatously thickened, with large often transversely elliptical pits, for about eight layers of cells immediately below the epidermis, and passes into a like number of thin walled cells by a transition through about three layers, while between this primary cortex and the cambium an abundant secondary cortex is developed, containing large fan-shaped abundantly crystalliferous dilatations of the principal medullary rays, between which lie broad wedges of bast. Except for a few small and scattered bundles of hard bast fibers in the pericycle, at the inner border of the primary cortex close beneath the collenchyma, none of the bast fibers become thick walled, but they remain as long wide generally irregularly collapsed tubes with oblique often clustered simple pits, and destitute of protoplasm. Traversing these bast wedges are a few secondary rays, while tangentially they are parted by plates of thin walled parenchyma cells from two to about five times as long as broad, with horizontal septa, a few rows of which contain crystals; and among these cells, rich in

* Hartig, Timbers and How to Know Them, 8.

† From an examination of Nördlinger's set of 1100 cross-sections of woods.— Cf. p. 78 of text accompanying century xi.

protoplasm, sieve tubes should be found.* The two systems thus map out the bundles, in cross-section, into a series of quadrangles.

Throughout, like the wood, the cortex is destitute of secretion passages. The cork, which is formed immediately next the epidermis † during the first summer, cuts off a bark which does not become very thick, and is interruptedly stratified by the intercalation of masses of condensed cells between layers of more open cells.‡ Grit cells are entirely absent, and I have not satisfied myself that the primary cortical parenchyma is added to below the cork by the formation of phelloderm from the inner limits of the latter.

In sections just below the nodes, fibro-vascular bundles may be found running obliquely upwards through the cortex, from the xylem to the leaf scars.§ The tracheary elements of these bundles are spirally marked as in the primary xylem next the pith, and they are unaccompanied by secretion passages. So far as I have observed, their transit through the cortex is effected in a vertical distance little greater than the thickness of the latter, so that they

* Van Tieghem and Lecomte (*l. c.* 181) speak of these tangential bands as consisting of "tubes criblés," and it is clearly in them that the sieve tissue should be found; but notwithstanding repeated examination of sections from fresh, dry and alcoholic material, which had been subjected to treatment which renders the sieve tubes of *Tilia*, *Magnolia*, *Ulmus* and other trees very evident, I have quite failed to demonstrate sieve plates in the cortex of this species.

† So far as can be judged from specimens still retaining the epidermis, but with fifteen or twenty layers of cork cells, the first subepidermal layer of cortical cells becomes active as phellogen; but as this is formed in the early summer of the first year, while I have been able to study only very young shoots and those which had ended the season's growth, I have been unable to get a preparation showing the first segmentation, which would afford conclusive information on this point.

‡ This is to be compared with the annual cork layers described for Balsamifluae by Reinsch, Engler's Bot. Jahrb. xi. 367.

§ The occurrence of true cortical bundles in various groups of plants is discussed by DeBary, Vergl. Anat. 266; Mueller, Engler's Jahrb. ii. 449; Gilg, Ber. Deutsch. Bot. Ges. xi. 21; Burck, Ann. Jard. Bot. Buitenzorg, vi. 156; Heim, Thesis, 18, etc.

really belong to the pulvinus of the leaf, but this does not prevent them from appearing as distinct cortical bundles in favorably located sections (pl. 39 and 44 f. 1–3). Three of these foliar bundles, corresponding to the three bundle traces evident on the scars marking the former position of fallen leaves, pass into each petiole, where they soon unite to form a closed crescent-shaped ring of bundles. No isolated bundles are contained within this petiolar ring, the parenchyma within which includes a series of about twenty secretion passages similar in structure and contents to those of the stem, with which, however, they have no direct communication. From the petiole, a group of resin passages runs through the midrib of the leaf, a single one passing out into each of the finer veins. Stellate crystals are of rather frequent occurrence through the petiole and midrib, both of which contain collenchyma.

The upper epidermis of the leaf blade is smooth walled except for a few striated cells about the bases of some of the hairs, and consists of a layer of inconsiderably thickened cells, beneath which lies a layer of quadrate cells each of which contains a large stellate crystal. A layer of similar cells is also found between the veins and the lower epidermis, the cells of which are somewhat smaller and prominently wrinkled on the outer wall, so as to appear almost muricate in cross section. The stomata are not sunken below the general level of the epidermis. Tannin appears to be abundant in the epidermal layers.

Pubescence consists of two kinds of hairs:— abundant, slender pointed thick walled hairs, usually with several transverse septa, especially toward the often bulbously widened base, and mostly isolated, but occasionally binate; and less numerous clavate hairs, septate both longitudinally and transversely, their small cells with yellow contents. These compound hairs are chiefly seen on the young stem, the sides of the petiole, and the upper surface of the midrib of the leaf. The epidermal cells about the bases of the hairs are usually divided by a septum parallel to the leaf

surface. The mesophyll is composed of two or, mostly, three layers of compactly placed palisade cells only a little longer than broad, occupying the upper half of the leaf, and a spongy parenchyma with ample intercellular spaces below. No spicular cells have been observed.

The structure of the roots is interesting to this extent, that (at least in lateral roots, which, alone, have been examined) they are entirely destitute of secretion passages, which are thus seen to be confined to the pith sheath of the stem, the intra-fascicular parenchyma of the petiole, and the parenchyma of the veins of foliar organs, including the carpels. The elements of the root are essentially similar to those of the stem, and secondary growth in thickness is effected in the manner usual in the roots of Dicotyledons.

While I have found comparatively little starch in the stem of specimens gathered either in November or in the spring, the medullary rays and cortical parenchyma of the root contain an abundance of roundish grains, often binary, and of extremely variable size.

Dr. Chapman, who described the genus *Leitneria* and its single species, placed it among the Myricaceae because of its simple flowers arranged in spike-like catkins;* and in this he was followed by DeCandolle.† Subsequently Baillon examined it, and placed it with doubt in his group of Castaneae, beside *Myrica*, making it, however, the representative of a series which he named Leitnerieae,‡ and in which he also placed with question a Madagascar genus, *Didymeles*. This series was raised by Bentham and Hooker § to ordinal rank, under the name given by Baillon, and placed between the Platanaceae and Juglandaceae, with an indication of Urticaceous affinities, *Didymeles* being excluded. The order is maintained under the name Leitneriaceae by Engler,‖ who places it between Myricaceae and Salicaceae.

* Flora So. U. S. 427.

† Prodromus, xvi. (2), 154.

‡ Hist. des Plantes, vi. 239, 258; Tison, in Baillon, Dict. de Bot. iii. 215.

§ Genera Plant. iii. 397.

‖ Engler and Prantl, Pflanzenfamilien, iii. (1), 28.

In 1886, Van Tieghem and Lecomte,* after a histological study of the stem and leaf, decided, because of the stratification of the bast and the occurrence of secretion passages in the pith sheath and the leaf, that *Leitneria* may be placed in or at least joined to the polypetalous order Dipterocarpeae, its macroscopic characters being also not unlike those of that family except for its diclinous reduced flowers. More recently Heim † has reviewed its histological characters, and reached the conclusion that its affinities are rather with the group Balsamifluae or Liquidambareae of Hamamelideae (likewise a polypetalous group, with which Van Tieghem and Lecomte had also recognized that it might be compared in certain respects), near which for both anatomical and organographic reasons he would place the Leitnerieae, while allowing it to retain its autonomy.

Many botanists look on the Apetalae as only a provisional aggregate of orders with reduced inflorescence, which must be disrupted before a truly natural system of classification is reached; and efforts have been made from time to time to distribute all of these orders among the Polypetalae and Gamopetalae, just as single apelatous genera and species are universally placed in orders otherwise characterized by the possession of more complete flowers. This problem is one that may be expected to receive aid from the many comparative histological studies now being made, especially by French and German botanists, though no purely organographic system dispensing with the Apetalae has yet met with more than limited approval.

Against the approximation of the Leitnerieae to the Balsamifluae, may be urged the absence of secretion passages from the liber, and the non-scalariform duct perforations, though the floral structure suggests a possible further simplification of the type of this group. On the other hand, the absence of secretion passages from the root, the

* Bull. Soc. Bot. de France, xxxiii. 184.

† C. Rend. Assoc. Franç. pour l'Av. des Sci., 1891, i. 231; Recherches sur les Diptérocarpacées, Thesis, Paris, 1892, 175.

narrow medullary rays, scanty wood parenchyma and hard bast, peculiar duct pattern, simple petiolar bundle arrangement, and the venation of the leaves, count against too close a union of the Leitnerieae with the Dipterocarpeae,—a conclusion which is further strengthened by the fact that no existing or fossil representatives of this order are known from the New World. For the present, therefore, the order Leitnerieae will probably be maintained either in the position it now occupies next the Platanaceae, or, in case of the dismemberment of the Apetalae, near the Dipterocarpeae or Balsamifluae among the Polypetalae; and on this point no one class of histological characters appears to be conclusive.*

The peculiar lightness and softness of the Missouri cork wood, combined with its slight porosity, suggest that it should find application in the arts if, as appears to be the case, it can be procured in suitable quantities for economical working, and while its small size bars it from very extended use, it is possible that it may prove a useful substitute for cork in the manufacture of bottle stoppers for chloroform and other gummy substances, which cause cork to tear badly after a little use.

* Attention should be called here to the close affinity which Agardh, Brongniart and Clarke have thought they saw between the Platanaceae and Balsamifluae.—On this point see Baillon, Adansonia, x. 134; Eichler, Blüthendiagramme, ii. 66, and, on anatomical grounds, Gris, Ann. Sci. Nat., ser. 5, xiv. 40, and Mémoire sur la Moelle, 267, and Reinsch, Engler's Jahrb. xi. 369. But Bentham and Hooker (Genera, iii. 396) do not at all agree with this conclusion.

EXPLANATION ON PLATES ILLUSTRATING LEITNERIA FLORIDANA.

The habit illustrations were drawn by Miss Grace E. Johnson, from living plants or herbarium material. The details are reproduced directly or redrawn from photomicrographs or drawings by the author.

Plate 30. — 1, Leafing twig, in spring; 2, autumnal leaf; 3, staminate catkin; 4, opening pistillate catkin; 5, branch with partly grown fruit. All natural size.

Plate 31. — 1, Pistillate, and 2, staminate shoots, in winter, natural size; 3, bud and leaf scar details, ×3; 4, stem hair, ×150; 5, exceptional, substellate arrangement of hairs, ×200; 6, base of hair, ×250; 7, glandular hair, ×180; 8, nature print of young leaf, natural size; 9, lower surface of old leaf, ×2.

Plate 32. — 1, Staminate flower, with portion of base of bract, and 2, dehiscent stamen, ×4; 3, ventral, dorsal, and lateral view of indehiscent stamen, ×9; 4, enlarged longitudinal section of a portion of a staminate catkin, showing fissuring of bracts; 5, part of a similar section, showing extrorse stamens and fissures of bracts and axis of inflorescence, ×18; 6, pollen grain from one end, and in optical section, ×400; 7, cross section of pistillate catkin, ×18, showing fissured axis at *a*, adnate base of bract with fissure at *b*, receptacle or disk with perianth, glands, and subtending bract at *c*, ovary with ovule and subtending bract at *d*, lower part of stigma with bract at *e*, and upper part of stigma with bract at *f*, — the sections belonging to successively lower flowers, in the order of lettering, — from one of a series of celloidin sections, retaining the several flowers and their parts in their natural position.

Plate 33. — Details of pistillate flower and fruit: 1, fully expanded pistillate catkin, natural size; 2, young flower with bract and scales from the inner side, ×5; 3, longitudinal section of young flower, showing disk and scales, ×18; 4, scales or segments of perianth, ×18; 5, longitudinal section of portion of catkin, ×18, showing lacunose axis and bracts, and pistil at point of separation from disk; 6–7, ovule entire and in section, ×18, — the bract at the left as in fig. 5; 8, fertilized ovary after fall of style, ×5; 9–10, partly grown fruits, with longitudinal and cross sections, ×2; 11, dried mature fruit, ×2.

Plate 34. — Cross sections of wood of stem, showing duct patterns, ×60.

Plate 35. — Similar sections, for the annual rings, the upper ×60, the lower ×125.

Plate 36. — Tangential sections of stem wood, the upper ×60, the lower, showing septate libriform, ×125.

Plate 37. — Tangential section of stem wood, above, showing dilated ray going to branch, ×125; and, below, partial radial section of stem, ×60, the xylem at the left, the phloem at the right,—showing complete duct perforations, stratification of liber, and serial arrangement of crystal cells in the latter.

Plate 38.— Cross section through wood and pith of stem, showing location of secretion passages, ×60; and radial section of pith, showing the greater transverse diameter of its cells, × 125.

Plate 39. — Cross section above, of outer part of wood and inner part of cortex, showing vernal row of ducts, quadrate liber, and, in the primary cortex, the small ducts of a foliar bundle; below, for comparison, a corresponding section of *Tilia Americana*, with quadrate bast wedges,— both ×60.

Plate 40. — Cross section of primary cortex of very young stem, showing epidermis and collenchyma; below, cross section of liber wedge, showing thin walled bast fibers with secondary rays and transverse parenchyma bands (the section torn through the cambium), — both ×125.

Plate 41. — Cross section of central portion of root, showing pith and xylem, — the large openings are ducts; below, longitudinal section of secretion passage in petiole, showing elongated form of secreting cells,— both ×60.

Plate 42. — 1, Enlarged radial section of stem xylem, showing medullary ray below, libriform cells at the right, striated transition to tracheides adjoining these, and striated tracheides with bordered pits at the upper left; 2, radial section, showing reticulated marking of medullary ray cells in contact with duct, ×400; 3, enlarged longitudinal section of duct, showing bordered pits and remnant of original transverse septum; 4, much enlarged cross section of wood, showing secondary thickening of libriform and medullary ray cells; 5, diagram of radial section of xylem crossed by medullary ray, ×200; 6, cross section, and 7, radial section of xylem, in diagram, ×200, showing parenchyma layer at annual ring,— the vernal wood at the right, the autumnal growth at the left; 8, diagram of tangential section of wood, showing libriform cells and medullary rays, ×200.

Plate 43. — 1, Radial section of xylem, showing libriform at the right, followed by tracheides, vessels, and wood parenchyma, the vessels subscalariform where adjoining a medullary ray, ×200; 2, cross section of secretion passage in pith sheath, ×320, pith at the left, xylem at the right; 3, radial section through the left hand portion of same, ×200, beginning with pith at the left, and ending with the secreting cells at the right; 4, cross section of outer part of pith (above) with stellate crystals, pith sheath, and innermost part of a xylem wedge, showing two spiral ducts, ×200; 5, radial section of outer cortex of old stem, showing stratified cork, ×200; 6, similar enlarged section of stem toward end of first season, showing phellogen layer and subjacent collenchyma; 7, tangential section of subepidermal collenchyma of young stem, ×200; 8, cross section, and 9, radial section of secondary bast, showing open bast fibers and interjacent bands of bast parenchyma, ×200.

Plate 44. — 1–3, Diagram of successively descending cross sections of young shoot at emergence of a branch, showing passage of the foliar bundles through the pulvinus and their union to form the petiole bundle, ×9; 4, collenchyma of petiole, ×250; 5, radial section of subjacent parenchyma, ×250; 6, cross section of secretion passage of petiole, ×350; 7, cross section of midrib and adjoining lamina of leaf, ×30, showing two forms of pubescence; 8, cross section of very young shoot, showing collenchyma, epidermis, and base of hair, ×200; 9, cross section of young leaf, and stoma, ×200, showing crystal layer of upper epidermis, palisade and spongy parenchyma, and striated lower epidermis.

By accident, the position of the ovule in the upper figure of plate 33, f. 8 is shown inverted, the true position being that indicated in the corrected figure here given.

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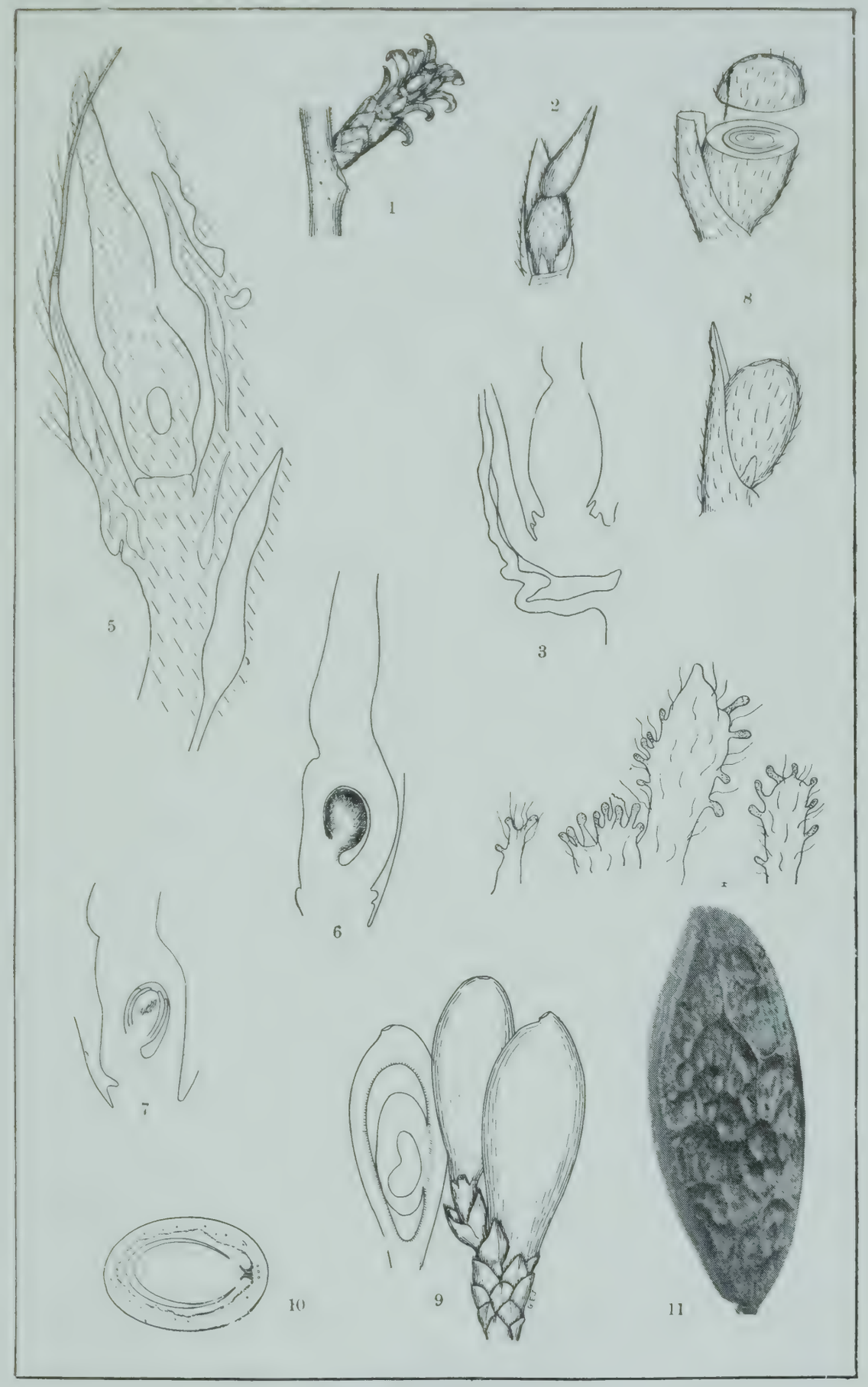

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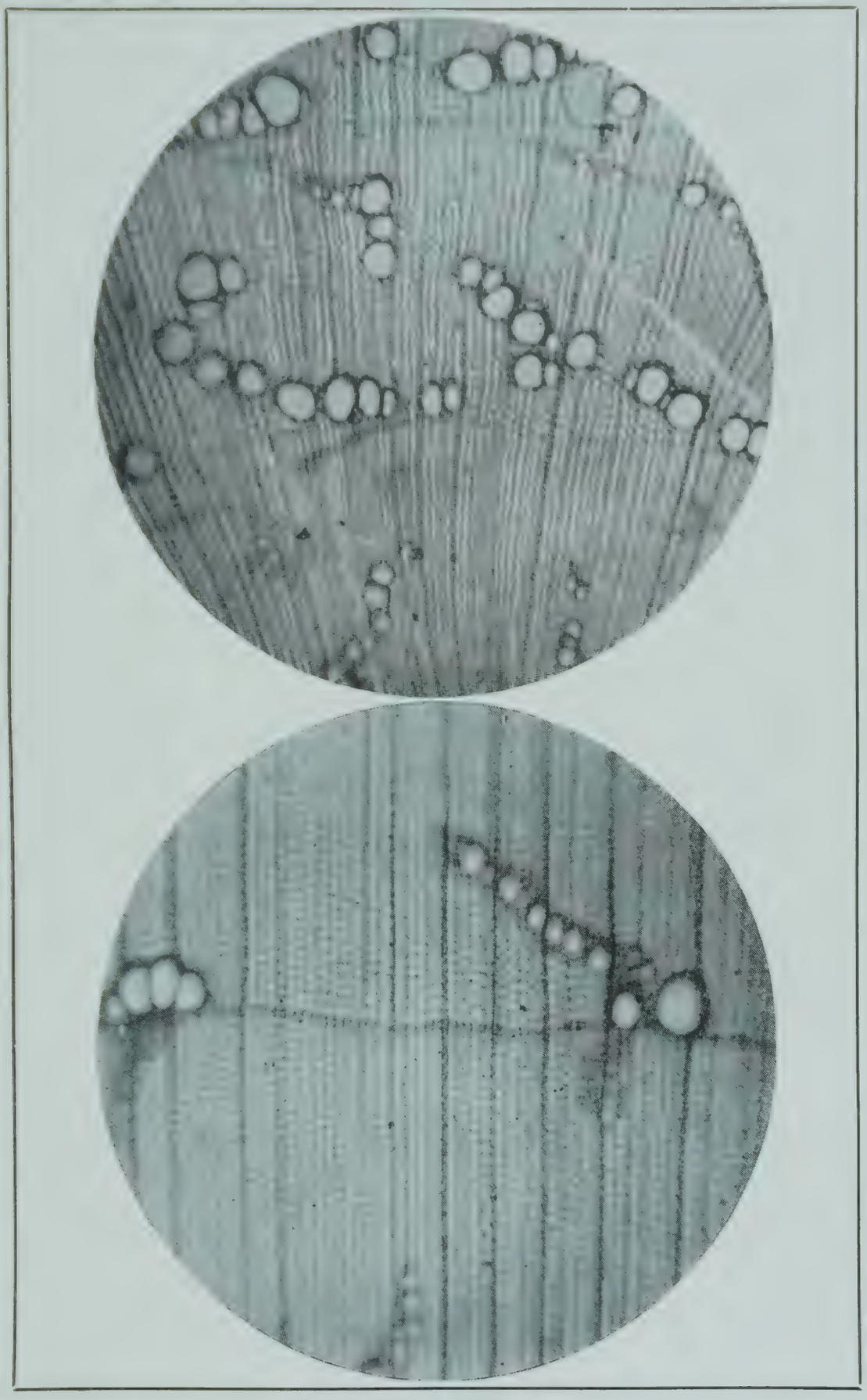

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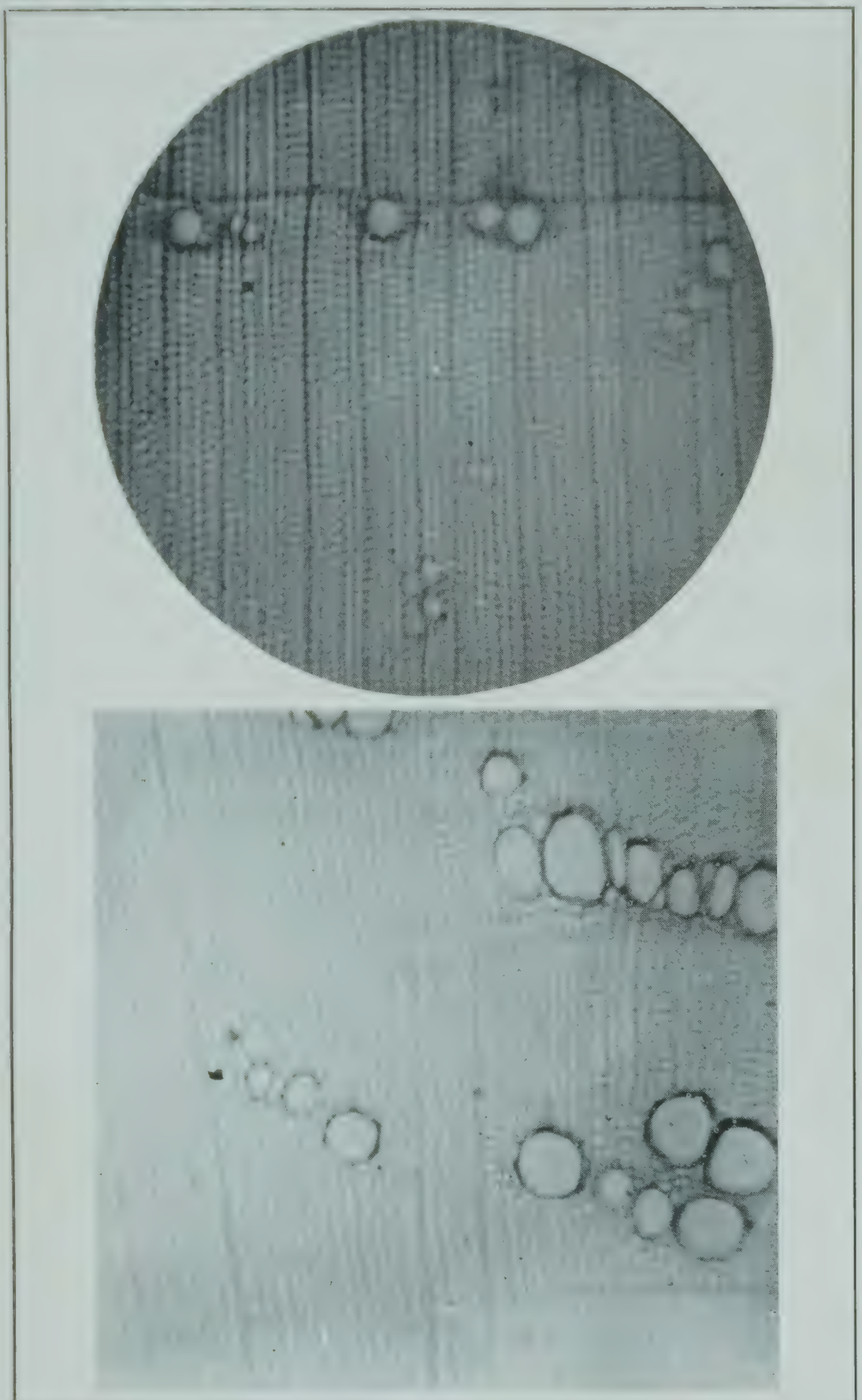

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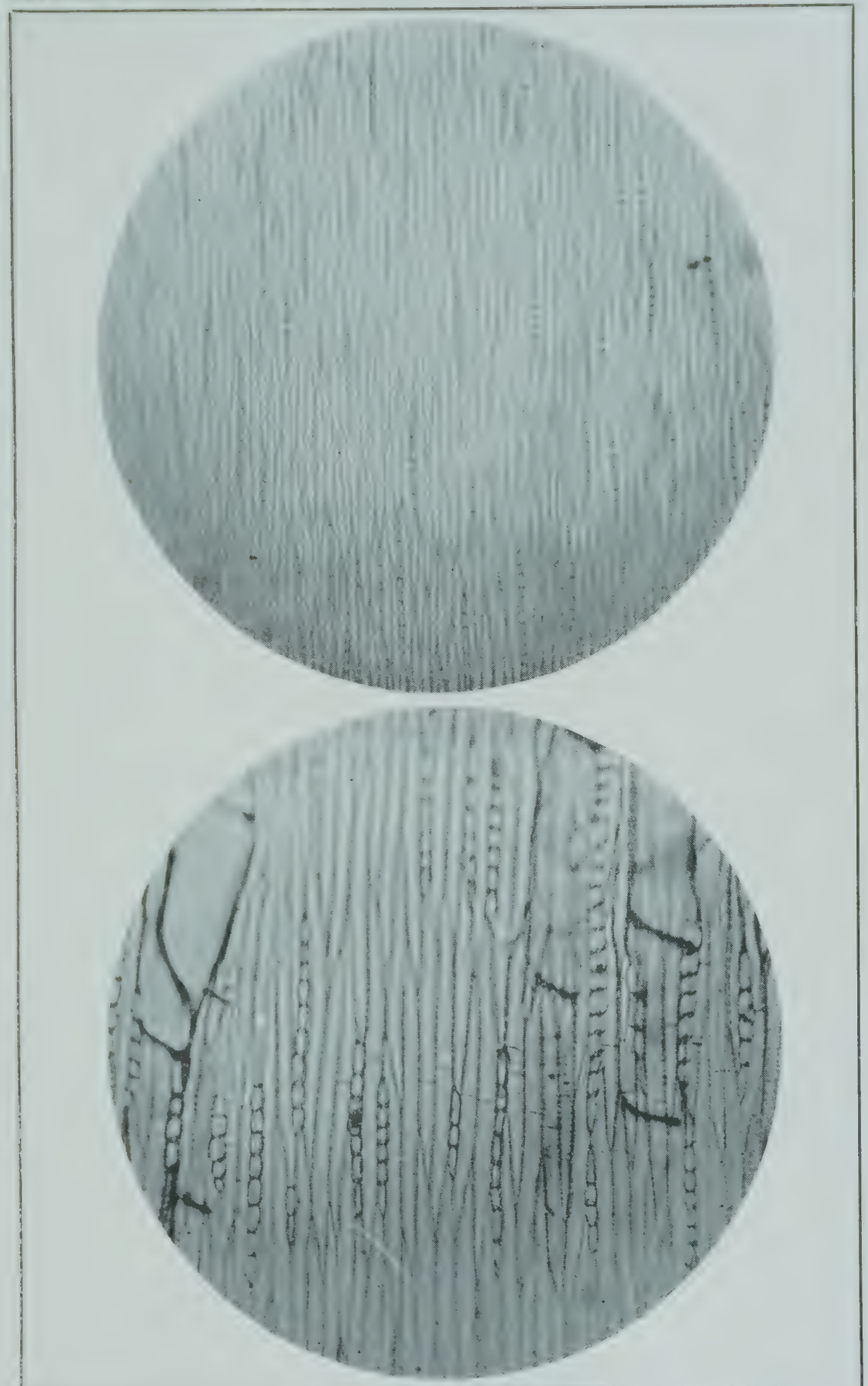

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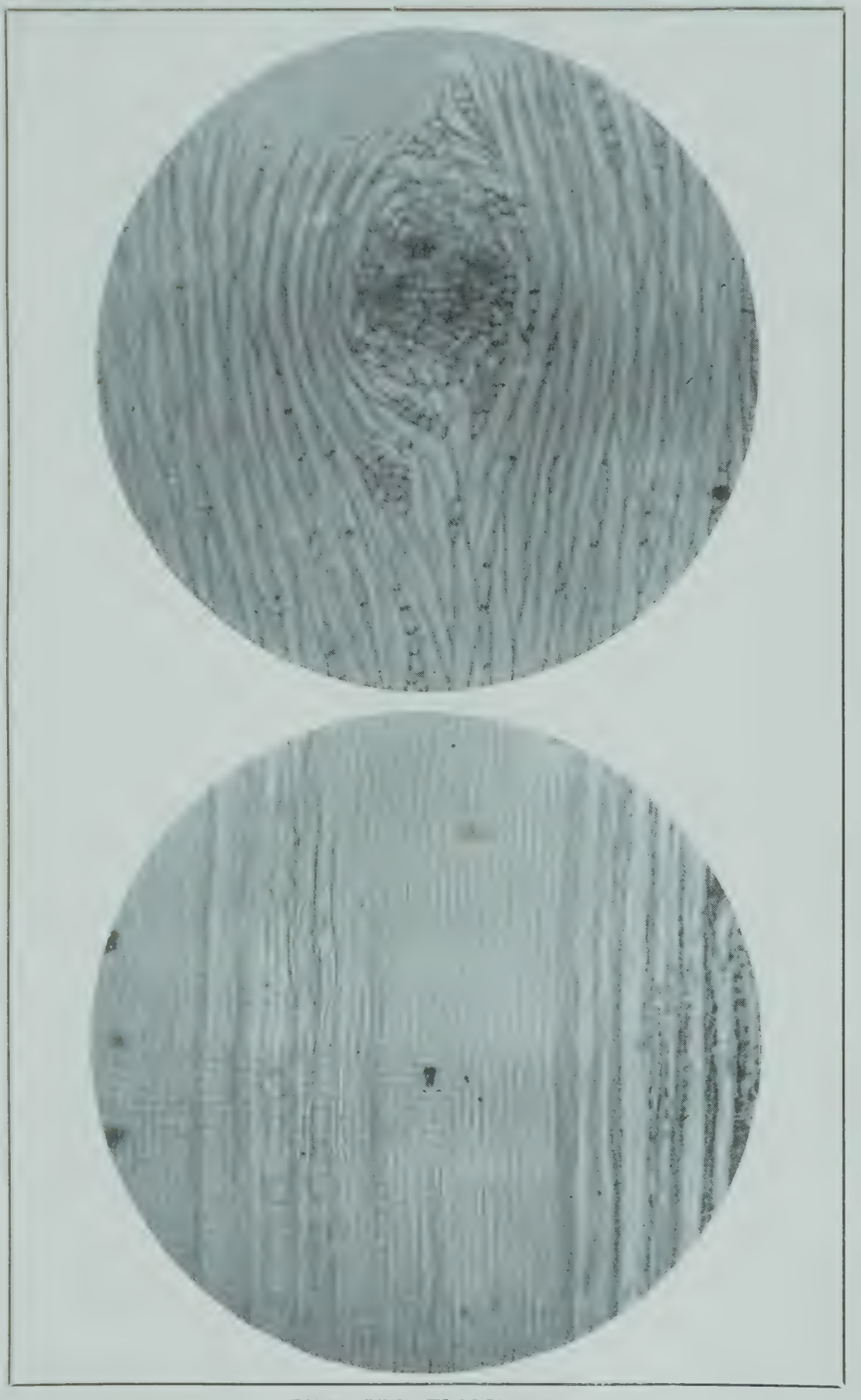

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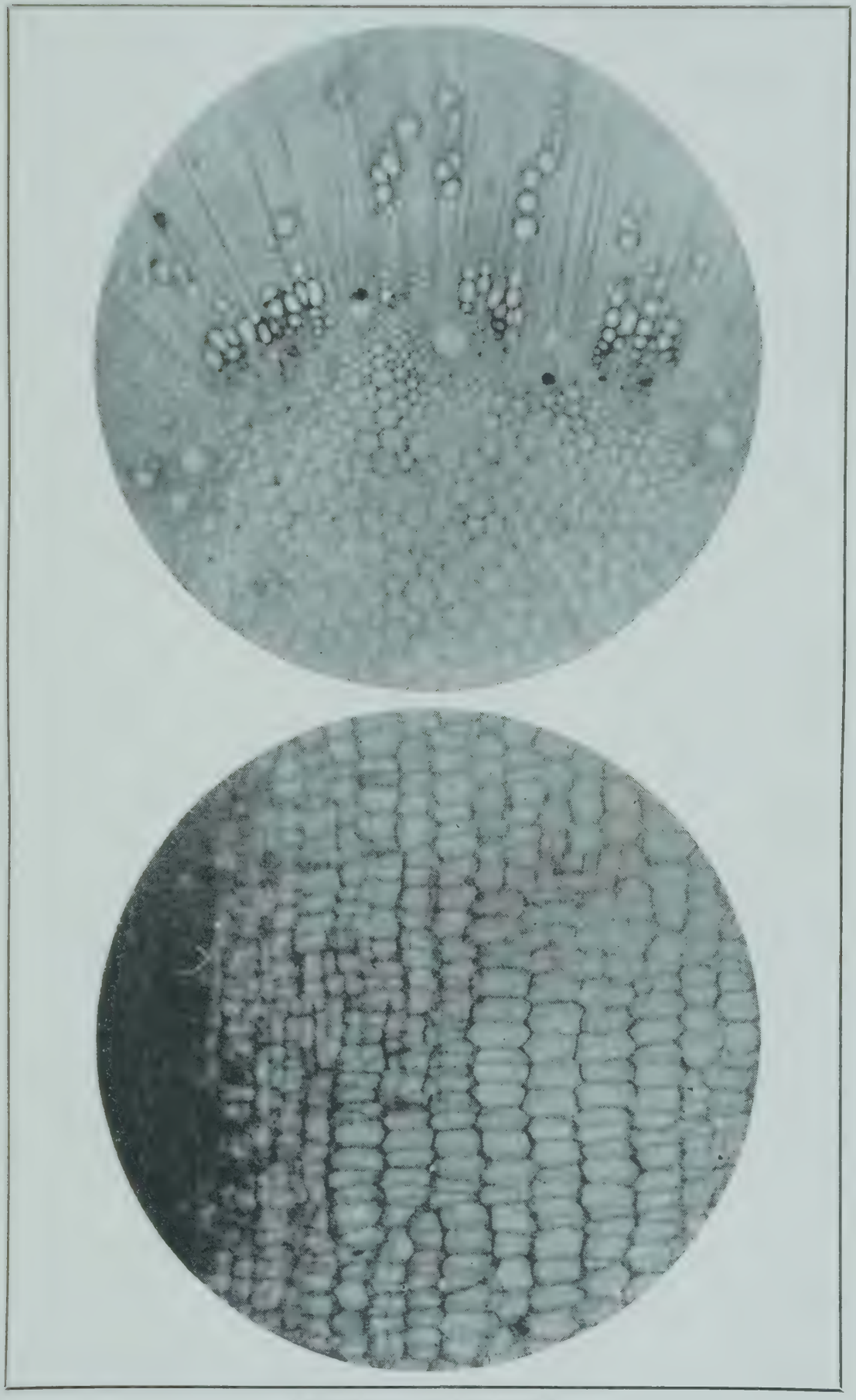

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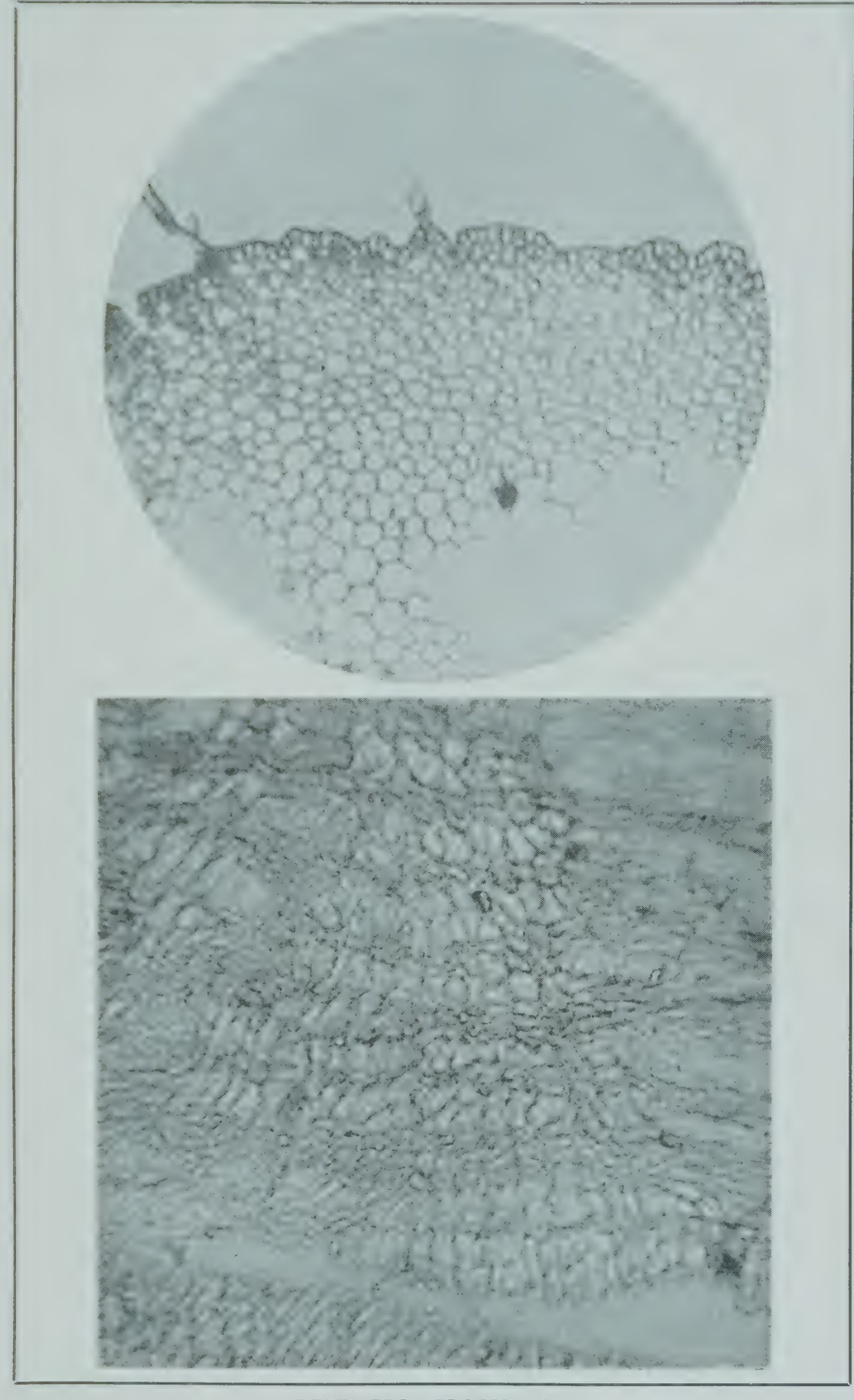

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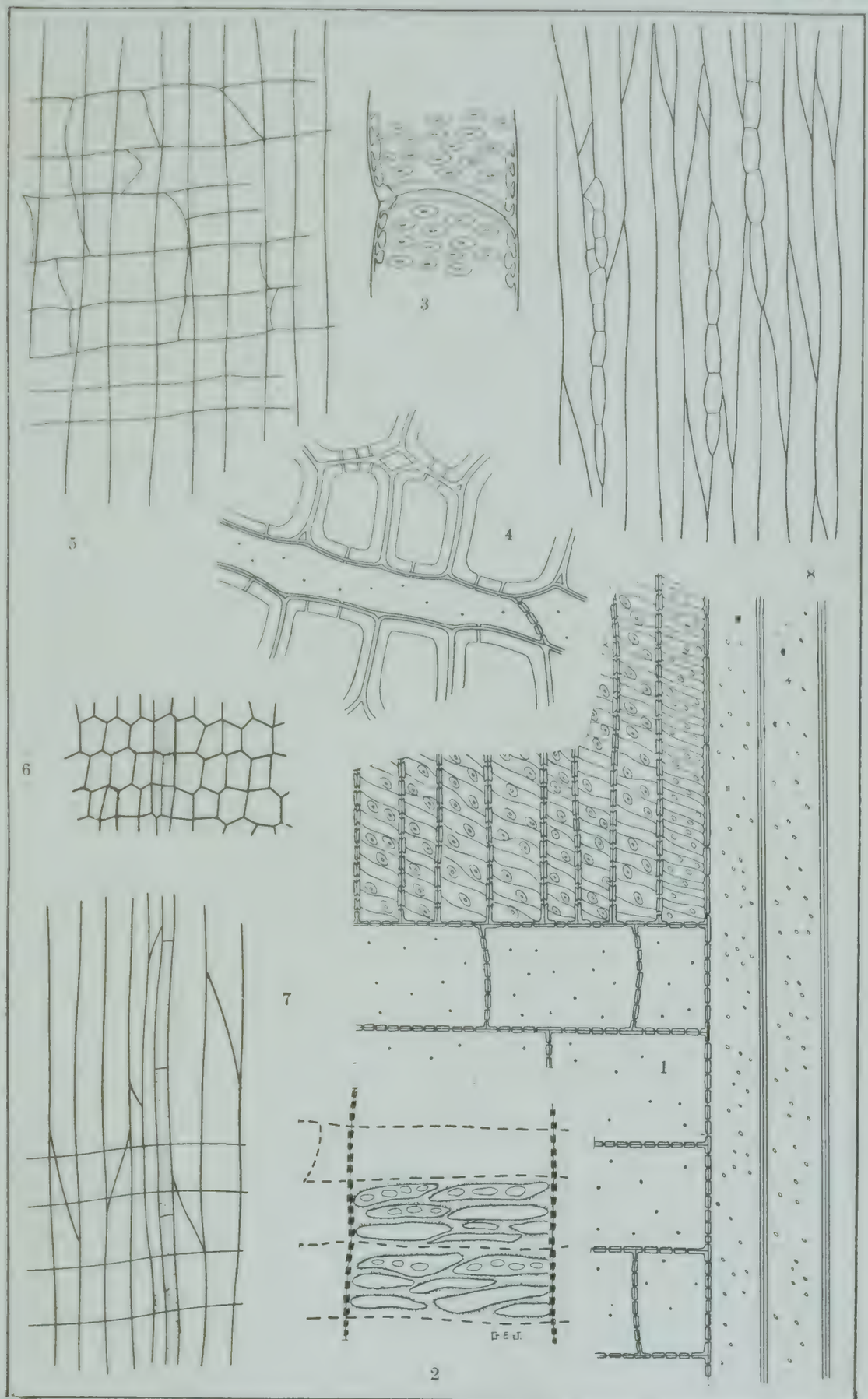

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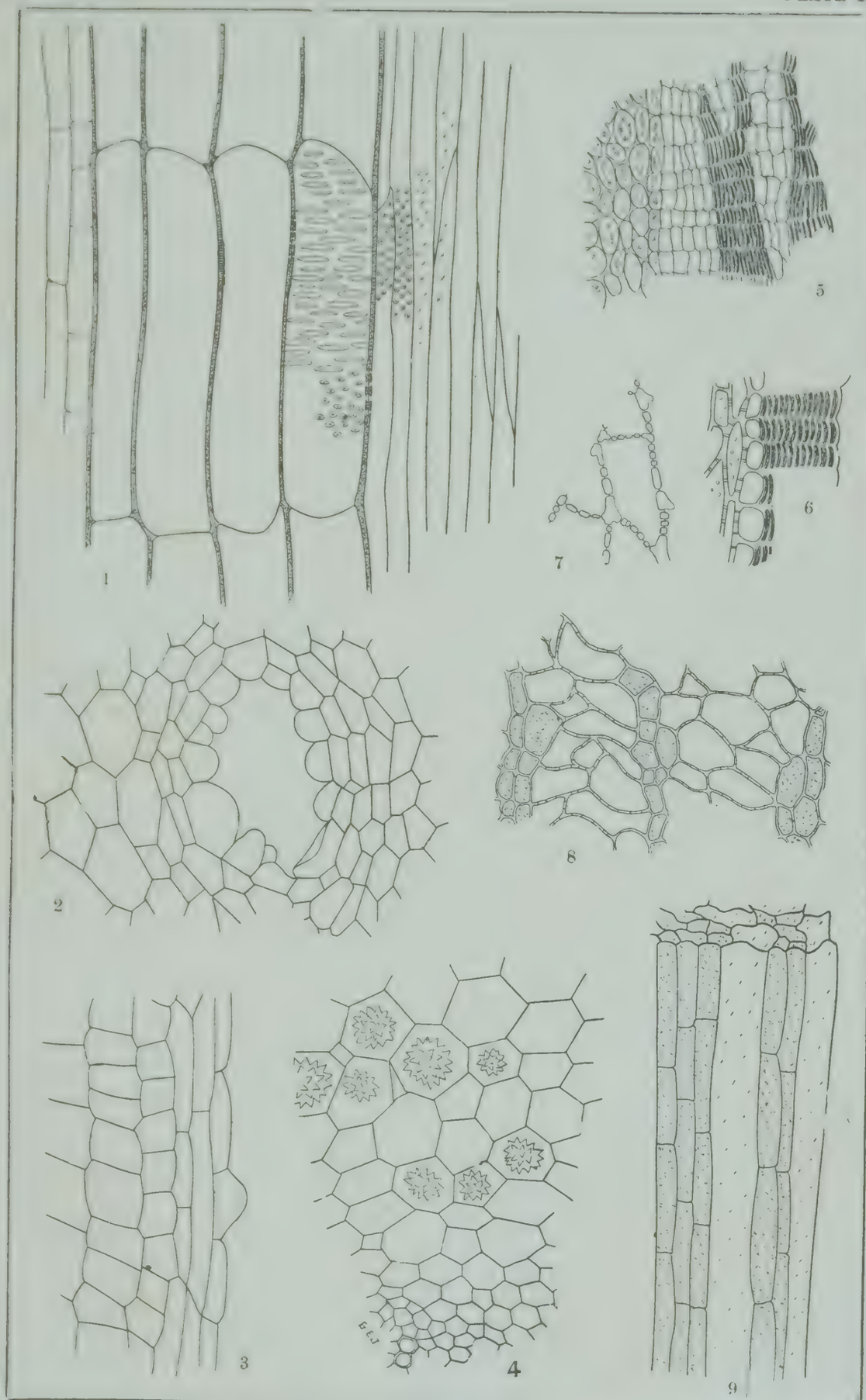

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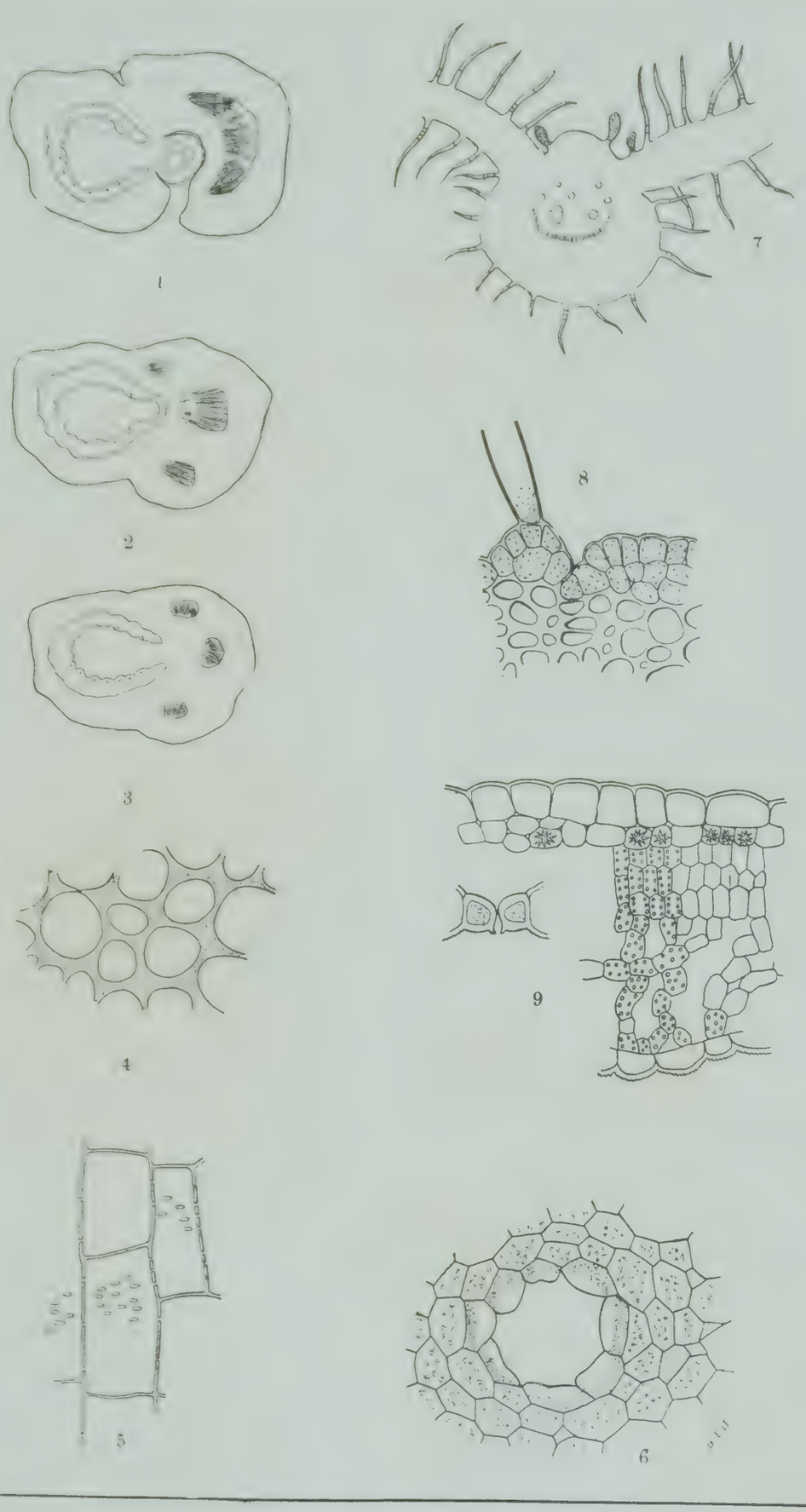

LEITNERIA FLORIDANA.

STUDIES ON THE DISSEMINATION AND LEAF REFLEXION OF YUCCA ALOIFOLIA AND OTHER SPECIES.

BY HERBERT J. WEBBER.

The Yuccas or Spanish bayonets, since the discovery of their peculiar and unique methods of pollination, have become objects of very general interest and study. It is, however, to the long continued and painstaking researches of Drs. Engelmann,* Riley † and Trelease ‡ that we are the most indebted for the very complete information regarding this phase of the ecology of the genus which we now possess.

The methods of dissemination in the various species of Yucca, while very interesting in many features, have as yet been very little studied. The only account that has come to the writer's notice is that given by Dr. Trelease in the closing paragraphs of his paper on the "Further Studies of Yuccas and their Pollination." § Here the adaptation of the different forms of Yucca fruits to different methods of seed dissemination is mentioned, and interesting observations are given on the dissemination of *Yucca brevifolia* and certain capsular species.

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* Engelmann, Geo., "The Flower of Yucca and its Fertilization." Bull. Torr. Bot. Club, Vol. III. (1872), pp. 33–37. — "Notes on the Genus Yucca." Trans. St. Louis Acad. of Sci., Vol. III. (1873), pp. 17–54.

† Riley, C. V., "On a New Genus in the Lepidopterous Family Tineidae, with remarks on the Fertilization of Yucca." Trans. St. Louis Acad. Sci., Vol. III. (1873), pp. 55–69. — "The Yucca Moth and Yucca Pollination." Mo. Botanical Garden, 3rd Annual Report (St. Louis, 1892), pp. 99–158.

‡ Trelease, Wm., "The Nectary of Yucca." Bull. Torr. Bot. Club, Vol. XIII. (Aug., 1886), p. 135. — "Notes and Observations. I. Detail Illustrations of Yucca." Mo. Botanical Garden, 3rd Annual Report (St. Louis, 1892), pp. 161–168. — "Further Studies of Yuccas and their Pollination." Mo. Botanical Garden, 4th Annual Report (St. Louis, 1893), pp. 181–226.

§ Trelease, Wm., l. c., p. 223.

There are three types of Yucca fruits which illustrate three distinct methods of dissemination. These types of fruits were used by Dr. Engelmann to distinguish the three groups of the true Yuccas.

Sarcoyucca: — Fruits pendent, fleshy, indehiscent; seeds thick and wingless, with ruminated endosperm.

Clistoyucca: — Fruits pendent, dry and coriaceous, indehiscent; seeds thinner than in Sarcoyucca, wingless; endosperm entire.

Chaenoyucca :— Fruits erect, capsular with septicidal dehiscence; seeds strongly compressed and thin with a winged margin; endosperm entire.

The Sarcoyuccas, comprising nearly one-half of the known species of Yucca, have sweet edible fruits and are apparently well adapted for dissemination by fruit-eating animals, especially birds. In this group the seeds are usually protected by the inner part of the ovarian wall, which in the development of the fruit becomes hard and firm, suggesting in texture and functions the core of an apple. The pulp is easily removed from the core, which is more or less shaped to the seeds. This structure would suggest that the pulp only is eaten, the core and seeds being thrown away. In this case, the fruits, it would seem, were intended to be carried away by the animals eating them in order to remove the seeds from the parent plant. Birds in picking away the tender pulp would hardly reach the protected seeds but merely remove the pulp, leaving the core and seeds. This would not serve the function desired. Certain species of the Sarcoyuccas, *baccata*, *valida*, and *Guatemalensis*, having the papery core, are said by Dr. Trelease † to fall early. It is quite probable that this is a habit developed to aid in their dissemi-

* Trelease, Wm., "Notes and Observations. 7. Yucca Guatemalensis Baker." Mo. Botanical Garden, 5th Annual Report (St. Louis, 1894), p. 166.

nation. They evidently fall as soon as mature while still soft and tempting to animals. If this is so they may be gathered regularly by certain small mammals that carry them about and eat merely the pulp, discarding the core and seeds as we discard the apple core. Such animals would be prevented by the reflexed leaves from climbing the stems of the plants and securing the fruits in this manner. It is thus necessary that the fruits fall in order that they may be secured and carried off. In *Yucca aloifolia*, with which we will have most to do, this core does not occur. In the still unripe but nearly mature fruits one may get a suggestion of it in the rather firm, white membrane which immediately surrounds the seeds. As the fruit matures, however, it becomes soft throughout and this is doubtless of decided importance in its dissemination as it thus affords no resistance or hindrance to birds eating the pulp from obtaining the seeds at the same time.

In regard to the dissemination of Sarcoyuccas, Trelease * writes "These fruits are well adapted to dissemination by fruit-eating animals, especially birds, the seeds being thrown away, but I do not know of any recorded observations on their dissemination." This was the condition of our understanding of their dissemination, when in the fall of 1892 I came to Florida and was afforded opportunity to study *Y. aloifolia* in its native home. One day a mocking bird was noticed picking at the pulp of the ripe fruits and this led to an investigation of the subject of its dissemination.

The fruit of *Yucca aloifolia* (Plate 47, fig. 1) is elongated elliptical in outline, with usually a slight central constriction, though this is by no means always the case. They sometimes reach a length of 15 centimeters but are usually from 8 to 10 centimeters long. In cross section (Plate 47, fig. 2) the fruit is hexagonal in shape, caused by the spreading of the nectar grooves in the ripening of the fruit. The openings of the septal nectaries may be seen

* Trelease, Wm., "Further Studies of Yuccas and their Pollination," l. c., p. 224.

in the upper portion of the ripe fruit on which the three lobed style remains plainly distinguishable, merely having slightly increased in size during the growth of the fruit (see Plate 47, fig. 1). The fruit is fleshy throughout with no indication of a core when fully mature.

In ripening, the fruit passes from green to purple and finally to dark purple or almost black in age. The pulp, which is very tender, is of a characteristic sweetish-bitter taste. The bitter principle is not evident for a few seconds after tasting the fruit; but like that of the Indian turnip, though not so strong, soon makes itself known and persists for a considerable time. Dr. Trelease* quotes Mr. Burbidge as having characterized the taste as resembling a mixture of black currant jam and quinine. The fruits vary somewhat in taste, some being quite pleasant and agreeable. A careful selection of the fruits for a number of years would, I think without question, result in developing valuable edible varieties. The fruits, it is said, are sometimes eaten by man. They, however, are surely not much sought and man only aids in their dissemination incidentally, spreading the plant by cultivating it as a showy garden perennial. It is popularly reported that people are occasionally made sick by eating the fruits.

Extended observations through three seasons have fully confirmed the fact that the mocking bird (*Mimus polyglottus*) is a very important factor in *aloifolia* dissemination, especially in what may be termed long distance dissemination. The mocking bird is very abundant throughout the range of *aloifolia* and may be the only animal disseminator of this species. At least I have not been able to observe any other bird or animal eating its fruits. It is not improbable that the fruit of *aloifolia* has become especially adapted for dissemination by the mocking bird or some small bird of similar habits. The core which occurs in all other baccate fruited Yuccas known to the author,

* Trelease, Wm., "Notes and Observations. 7. *Yucca Guatemalensis* Baker," l. c., p. 166.

would be fatal to dissemination by birds of this size and nature.

Numerous fruiting plants of *aloifolia* have been examined and, in almost every case, some or all of the fruits were found to be somewhat eaten. Sometimes only a small portion of the pulp will be eaten, but again a large part of the fruit will have been removed.

The seeds of *aloifolia* are comparatively thick, being usually from 2 to 2.5 millimeters, and have a narrow two-edged rim (Plate 47, fig. 4). They are blackish, nearly the color of the pulp, and lie imbedded in this tender substance but a short distance below the surface. The birds in picking off portions of the pulp, which is apparently a delicate morsel for them, soon come to the seeds. These they evidently do not want, but in their greediness they cannot avoid swallowing some of them. The birds, while usually quite shy, may yet with a little perseverance be observed in all the details of feeding. As portions of the pulp are deftly picked off, frequently a seed will adhere to the bill by the surrounding sticky pulp. Many times I have seen the birds throw off these seeds by a sidewise jerk of the head as a chicken does in trying to remove dirt or hair from its bill. This results in throwing the seeds to a considerable distance, frequently from 1 to 2 meters. Many of the seeds taken with the pulp are apparently swallowed. All of the seeds removed from the fruits through the agency of the birds are not thrown to a distance in this manner or swallowed, but many of them are merely loosened and drop down into the compact rosette of erect leaves below. These either adhere to the leaves by the sticky pulp surrounding them or, if dry, roll down the leaves to the stem where they are effectually lodged. All over the upper portion of the plant in this stage, portions of the pulp are scattered, which were accidentally thrown off with the seeds or dropped by the birds in eating. These portions frequently contain seeds.

While the fruits of *aloifolia* are in this bird-disseminat-

ing stage the leaves immediately below the fruit cluster are erect, that is, point upward forming an angle of from 30° to 60° with the stem. They are linear lanceolate and rigid with sharp horny end spines, and are usually from 35 to 65 centimeters long by from 3 to 5 centimeters wide. They are very numerous and suddenly broaden out at the base, greatly overlapping each other, so that an almost closed cup is formed at the apex where the fruit cluster is borne. The most of those seeds which fall, not being twitched off by the bird, strike some one of the numerous upper leaves and adhere until the rain washes them down to the stem where they are held till a later stage of development when the upper cluster of leaves, which are now erect, have become reflexed. This stage will be described in detail later.

Many of the seeds are evidently swallowed by the mocking birds with the surrounding pulp. In this case, as in the majority of pulpy fruits, the seeds are swallowed uninjured and resist the action of digestion so that they pass through the alimentary canal and are evacuated in good condition for germination. Mocking bird dung, which had fallen on the Yucca plants, was examined in many cases and frequently found to contain *aloifolia* seeds apparently uninjured.

The stomachs of several mocking birds were examined, but, although in three cases almost the entire contents of the stomach was composed of the pulp of *aloifolia*, no seeds were discovered.

Having at my home a captured mocking bird I tested him with *aloifolia* fruits and seeds. He had become quite tame and had learned to pick flies from one's finger. I first took single seeds surrounded by some pulp. These he greedily picked from my finger and swallowed without difficulty. During the feeding several seeds were snapped from his bill, and several were thrown off by a twitch of the head in trying to free the pulp from the seeds. These actions correspond exactly with those previously observed in the field. The number of seeds swallowed was

counted. One seed made the passage of the alimentary canal and was evacuated in fifteen minutes after the first seeds were swallowed. At the end of an hour all of the seeds which were swallowed had been evacuated. The next day I gave the bird fifteen *aloifolia* seeds from my finger at one feeding. In half an hour thirteen of these had been evacuated and the others were evacuated before the end of the hour.

I next gave the bird an entire fruit and watched him pick off portions of the pulp, occasionally getting a seed. The cage previous to this had been thoroughly cleaned. During about four hours, the time he was given access to the fruit, he ate and evacuated fifty-one seeds.

All of the details of the feeding were watched many times with this tame bird and the important features of the feeding, snapping and twitching the seeds, etc., were found to correspond entirely with what had been observed in the field.

The seeds which were evacuated were apparently in good condition, but to surely determine this a number of them were planted. A very fair percentage of these germinated and formed healthy young plants.

During the fall and winter, from November to February, when the *aloifolia* fruits are ripening in greatest abundance and are suitable, they apparently form the main food of the mocking birds, judging from the frequency with which one observes them feeding on the *aloifolia* fruits, and from their excrement at this season of the year. In early fall, during September and October, many *aloifolia* fruits ripen, but at this season of the year the poke berry (*Phytolacca decandra*) and the wild and cultivated persimmons are conspicuous rivals as mocking bird food. By the middle of November these are principally gone, however, or remain as dried fragments. The fruits of *Duranta Plumieri* Jacq. and *Melia Azederach* L. play some part in supplying food for the mocking bird in late fall and winter.

While the fruits of *aloifolia* are almost always more or

less eaten by the mocking birds, and many seeds removed, yet by far the larger portion of the fruit with its contained seeds usually remains still hanging on the old fruit cluster. The pulp of the fruit gradually dries up and shortly but little remains of the heavy pulpy fruit but a light mass of seeds cemented together by the dried up pulp. The breaking of the epidermis and eating here and there on a fruit by the mocking birds greatly hastens this drying. As the fruits dry they pass the stage when birds aid in their dissemination and now a secondary method of local dissemination begins to act.

As the lower fruits of the cluster in *Yucca aloifolia* reach maturity, one or more, seldom two or even three, lateral buds, start up near the base of the peduncle and prolong the growth of the stem. A single bud soon simulates the continuation of the main axis. Several buds form a branched trunk.

In every case examined the bud or buds appear to develop from the axil of a leaf about one series below the inflorescence, and in its development the bud quite uniformly splits the base of the leaf which is directly above it. This is somewhat at variance with the observations of Dr. Mellichamp * who found the bud of *aloifolia* to spring from exactly the uppermost axil, at the base of the inflorescence.

The new rapidly growing shoot, which develops from this bud, grows up within the circle of mature leaves beside the old fruit cluster (Plates 45 and 46); which is pushed to one side by the growth of this secondary branch, which in turn bears an inflorescence.

Whether the inflorescence of Yucca is truly terminal, morphologically speaking, and the bud lateral, I have not yet been able to determine. Engelmann † speaks of the inflorescence of Yucca as terminal; and Trelease mentions

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* Quoted by Dr. Engelmann in his "Notes on the Genus Yucca." Trans. St. Louis Acad. Sci. III. (1873), p. 22.

† Engelmann, Geo., "Notes on the Genus Yucca," p. 25. Reprinted in "The Botanical Works of Geo. Engelmann," p. 282.

the inflorescence of *Yucca brevifolia* as terminal: "After blooming, two or three stout branches usually develop by the side of the original apex, which now has ended its growth. When these have reached a length of two or three feet each forms a *terminal* inflorescence and branches in its turn, giving rise to a repeated forking or tripartition." * It does not appear, however, that a morphological examination has been made to determine this point. In the lack of definite information, I speak of the inflorescence as terminal and the buds as lateral in this paper.

The periodical development from the base of the inflorescence, of the lateral buds which continue the stem in *aloifolia* and some other Yuccas, results in forming a trunk consisting of a certain number of units or segments which are quite distinct. These may be designated ecological phytomers or *phytomeroids*.† The branches formed at the side of the old fruit cluster do not usually bloom the next spring, but spend a year in their development, bloom the second spring, and fruit the second fall or winter after they start to develop. A period of two years is thus required for the completion of one of the phytomeroids. No exceptions to this have been observed though they probably occur. Some plants bloom very early in the spring and mature their fruits early in September. It is quite probable that the lateral shoots of these early blooming plants may succeed in making a sufficient growth to bloom the next spring, probably rather late, and mature their fruits the next

* Trelease, Wm., "Further Studies of Yuccas and their Pollination," l. c., p. 194.

† From phytomera (φυτον, plant and μερος, part) and ειδος, form Phytomera or phytomers was used by Gray (Gray's Botanical Text Book, 6th Ed., Vol. I., Structural Botany or Organography on the Basis of Morphology, p. 7), to designate the units of a stem, each including an internode and node with its leaf.

Phytomeroid as used here is apparently equivalent to what Gray has called *definite shoots* (l. c. p. 49), and is what in German is known as *Langtrieb*, *Haupttrieb*, etc. (R. Hartig, "Lehrbuch der Anatomie und Physiologie der Pflanzen," p. 116. Pax, "Allgemeine Morphologie der Pflanzen," p. 24.)

winter. I am satisfied, however, that this is not frequently the case. It is probable that certain branches may also require more than two years for their development before fruiting. I am inclined to think this not uncommon though no specimens under continuous observation have been known to do so.

One of the most marked and peculiar characters of *Yucca aloifolia* and a number of other Yuccas is the reflexing of the leaves. The reflexing does not take place gradually as the leaves are formed, but corresponds with the phytomeroids of the stem mentioned above. Only the leaves belonging to the upper phytomeroid are erect, those of the preceding older phytomeroids are all reflexed more or less strongly, becoming more and more closely appressed to the stem the nearer they are located to the base. All of the leaves belonging to a certain phytomeroid become reflexed at the same time, and this reflexing takes place at a certain stage in the development of the fruit and lateral shoot. About the time that the lateral shoot or shoots which form at the base of the old fruit cluster start their development, the leaves of the upper phytomeroid to which the old fruit cluster belongs, begin slowly to reflex. As the lateral shoot develops they become more and more strongly reflexed till by the time the lateral shoot is half grown they have in most cases come to point strongly downward and form an angle of some 45° or less with the stem (Plates 45 and 46). This angle grows less and less each year until the leaves have become closely appressed to the trunk. They finally die and dry up, but remain persistent, clothing the lower portion of the trunk (Plate 46). In cultivated *aloifolia* these are usually pulled off to render the plants more sightly, a practice liable to cause a misunderstanding of the true habit of the plant unless this is remembered.

The leaves of the lateral shoots which start at the base of the old inflorescence, remain rigid and erect all through their growth and during flowering, as long, indeed, as these

lateral shoots form the uppermost phytomeroid. As the fruits which they bear ripen and lateral buds in turn start at the base of their fruit stems, they cease to be the terminal phytomeroids and their leaves begin to reflex.

The leaves of the upper phytomeroid while in the erect stage are separated by a wide angle of divergence from the reflexed leaves of the preceding phytomeroid, the point of divergence being usually very marked (Plates 45 and 46).

The phytomeroids of the trunk are usually from one to two feet in length and easily distinguishable even in the old lower growths. A slight swelling in the trunk frequently marks the place where one growth ended and the next began.

The reflexing of the leaves is evidently due to a strong epinastic growth of the tissue at the base of the leaf. The tissue on the under surface at this point collapses under the pressure exerted and becomes somewhat wrinkled.

The time occupied in the reflexing of the leaves of a phytomeroid varies considerably. The first marked reflexing takes place quite rapidly, but the gradual drying and compressing against the stem is a slow action, running through several years. On starting to reflex, the leaves pass below the horizontal and come to point downward in from one to three months. After becoming reflexed, the leaves remain fresh and apparently active through the development of about two other phytomeroids, after which they begin to dry up and finally die. The length of time which they remain living apparently depends largely upon the conditions to which the plant is exposed. Plants growing on the sterile sand dunes along the coast or in old neglected yards usually have very short leaves, which after reflexing live only for a short period. Usually all leaves are found to be dried up in such cases except those on the two upper phytomeroids. Occasionally only those of the uppermost phytomeroid will be found perfectly fresh and

active, the leaves beginning to dry up as soon as they become reflexed. In plants grown in rich soils or in well manured yards, the leaves of two or three phytomeroids may frequently be found green and apparently active.

While the reflexing of the leaves in *Yucca aloifolia* is probably not primarily to serve as an aid in seed dissemination it is yet certain that it is of considerable service in this direction. The seeds which are dislodged by the mocking birds in feeding, as described above, being heavy fall into the crown of still erect leaves below, where they usually adhere to some one of the numerous leaves or slide down to the apex of the stem where the almost closed cup formed by the broad bases of the leaves effectually arrests and retains them until a later period of development when these leaves become reflexed. If on the contrary the falling seeds rattle through the cluster of erect leaves of the upper phytomeroid, on reaching the upper reflexed leaves of the lower phytomeroid which point downward and outward, they are shot outward by these, the force of the fall serving to throw them to a considerable distance from the parent plant.

When the leaves of the upper phytomeroid, that bearing the fruit cluster, have become reflexed, the seeds which have been lodged in the cup formed by these before their reflexion, are gradually dislodged and are thrown outward by the reflexed leaves as they fall. Many may be dislodged by rain and washed downward but can hardly fail to be thrown outward as far as the ends of the leaves of the parent plant. Those seeds which fall when dry are frequently thrown outward to a considerable distance. The majority of them strike the ground from one to one and one-half meters distant from the base of the parent plant. This distance depends on the height of the plant and the angle to which the leaves are reflexed. I have examined some typical but exceptional cases, where the seeds could noticeably be seen to form a circle around the

plant at a distance of about a meter, having been thrown there in falling by the action of the reflexed leaves.

While this is not the main method of dissemination, I think that it may reasonably be claimed to form a secondary method of considerable importance.

After reaching maturity the fruits remain fresh and soft for a few weeks but gradually dry up until nothing remains but a dried fragment of the pulp which cements the seeds together into a small light mass. Long before they have reached this thoroughly dry condition they have passed the stage when the birds will eat them. Sometimes the dried fruits are broken off as a whole and these, falling, strike the reflexed leaves and are thrown outward to some distance as they fall to the ground. The fruits may now be knocked about by man or animals or may become disintegrated in the place where they fall. This would also serve to disseminate the seeds to some extent. Many of the seeds still remain sound and evidently capable of germination.

A still more peculiar aid to dissemination is found in the larvæ of the Bogus Yucca Moth (*Prodoxus decipiens* Riley) which is very common here and probably throughout the *aloifolia* region.

The eggs of *Prodoxus* are deposited principally in the young flower stem, though it is said by Riley * that they are also found frequently breeding in the fruits of the indehiscent Yuccas like *aloifolia*. I have never observed them in the fruits of *aloifolia*, though I have made no special attempt to find them. The incision on the young peduncle made by the ovipositor leaves a discoloration and forms ultimately a sort of cicatrice which remains distinctly visible and as the stem dries becomes slightly elevated (Plate 47, fig. 3, b). The larva burrows in the tissue of the peduncle, molts according to Riley three times, and acquires full growth in a month. "It prepares for hibernation in the autumn, a cocoon of white

* Riley, C. V., "Yucca Moth and Yucca Pollination," Mo. Bot. Garden, 3d Annual Report (St. Louis, 1892), p. 128.

silk which is covered on the outside with castings and which remains protected within the stem. Before making the cocoon, however, it generally eats a passage way to the outer covering of the stem and lines this with silk leaving but a thin cap." During the time that the fruits are drying up, as described above, the larvæ of *Prodoxus* are particularly active and in many cases their burrowing succeeds in cutting the peduncle entirely off so that the fruit cluster falls to the ground. I have seen many clusters cut off in more than one place so that they are separated into several fragments. These portions of the fruit cluster may each retain attached a number of the old more or less dried up fruits containing many good seeds. As the fragments of the fruit cluster fall they are not lodged in the leaves as they undoubtedly would be if these remained erect; but are directed outward so that they fall, as we have seen that the seeds and single fruits do, on the ground a short distance away from the parent plant. The dried fruits are very light and the cluster with the protruding pedicels of the old flowers, is easily caught and dragged about by animals or man. Many of the seeds may be disseminated in this way.

The lateral branch which shoots forth at the base of the fruit cluster, starting its growth about the time that the fruits ripen, grows rapidly and by the time the fruits have passed the bird stage and approached the stage when the cluster is commonly cut off by the *Prodoxus* larvæ, the growth of the lateral branch has pushed the fruit cluster considerably to one side. By this time the leaves of the phytomeroid which bore the fruit cluster have usually reflexed below the horizontal so that they allow the old fruit cluster, when cut off, to fall to the ground without resistance or hindrance and direct it outward and away from the parent plant as it falls.

The cut end of the peduncle is usually smooth, showing that the cut was extended entirely across the stem with the exception of a very thin portion on the outside. This is

evidently partially cut through and that which remains is dry and brittle and breaks off by the weight of the cluster (Plate 47, fig. 3, a).

The seeds of the old dried fruits are frequently injured by the ravages of a beetle which burrows in the dried pulp and seeds. Many of the seeds, however, remain uninjured and apparently long retain their power of germination.

It is probable that the other *Sarcoyuccas* show the same leaf reflexion that occurs in *aloifolia*, but the periods of growth and other details may vary. So far as can be determined from photographs and drawings of the various species of Yucca, it appears that of the *Sarcoyuccas*, *baccata*,* *Guatemalensis*,† *Schottii*,‡ *australis* § and *macrocarpa* ‖ show this periodic leaf reflexing. Other species may show the same phenomena but no data are at hand from which this can be determined.

Of the *Clistoyuccas*, *brevifolia* ¶ evidently shows beautifully this periodic leaf reflexing, the old trunk remaining covered by the persistent, reflexed, dried up leaves which in age become closely appressed against the trunk.

Among the *Chaenoyuccas*, *Y. elata*, a stemmed species which grows to a considerable height forming a rather large tree in Arizona, is particularly interesting from the fact that here among the capsular Yuccas according to Dr. Trelease ** we find a counterpart of *aloifolia* in that the

* Trelease, Wm., "Notes and Observations. 1. Detail Illustrations, of Yucca," l. c., Plate 2.

† Trelease, "Further Studies of Yuccas and their Pollination," l. c., Plates 1 and 2.

‡ Trelease, as in last citation, Plate 3.

§ Trelease, as in last citation, Plates 4 and 5.

‖ Merriam, C. Hart, "Notes on the Geographical and Vertical Distribution of Cactuses, Yuccas, and Agave, in the Deserts and Desert Ranges of Southern California, Southern Nevada, Northwestern Arizona and Southwestern Utah." In "The Death Valley Expedition; A Biological Survey of Parts of California, Nevada, Arizona, and Utah. Part II," North American Fauna, No. 7, p. 358, Plate 14.

¶ Trelease, as above, Plates 6, 7 and 8.

** Trelease, Wm., "Further Studies of Yuccas and their Pollination," l. c., p. 202, Plate 10.— Also "Detail Illustrations of Yucca," l. c., Plate 9.

leaves become reflexed and persist on the lower portion of the trunk, becoming dry and closely appressed. The prolongation of the trunk is also by lateral buds springing from a point near the base of the peduncle. This species has a much longer peduncle than any of the *Sarcoyuccas* known to the writer and the inflorescence and fruit cluster are raised considerably above the leaves so that these apparently do not aid or interfere in any way in the dissemination of the seeds. If this species is modified for wind dissemination, as is the case with most capsular Yuccas, this elevation of the fruit cluster on a long peduncle would be of decided advantage.

The ecological significance of leaf reflexion in *aloifolia* and other Yuccas is not very evident. Prof. Lester F. Ward * has suggested that the reflexing of the leaves in the succulent fruited Yuccas has for its function the protection of the sweet pulpy fruits from the ravages of small animals such as the raccoon, opossum, rodents, etc., which might injure the seeds if the fruits were eaten by them. Any animal attempting to climb the trunk of *aloifolia* or other species having these reflexed leaves, meets an almost impenetrable barrier in the numerous sharp spines of the stiff reflexed leaves which cover the older portions of the trunk, pointing downward like so many bayonets. Should they attempt to reach the cluster of fruits by jumping up from below in the case of low plants, or by jumping down on them from neighboring trees, they are met by the rigid points of the erect leaves of the upper phytomeroid, which remain erect till the fruits begin to dry up and pass their desirability.

Dr. Trelease † mentions having found fruits of *baccata* in the crown of leaves where they had fallen on maturity and had remained protected from rodents by the reflexed leaves.

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* In a paper read before the Washington Biological Club.— Unpublished.

† Trelease, "Further Studies of Yuccas," l. c., p. 186.

As the leaves of this phytomeroid become reflexed these fruits would be freed and fall to the ground.

Dr. Merriam * mentions the reflexed leaves of *arborescens* (*brevifolia*) as effectually preventing most animals from climbing up the trunk from below. Dr. Merriam informs me, however, that the wood rat succeeds in ascending the trunk. I quote the following from a letter of February 6th, 1894: "Mr. Vernon Bailey and I have examined many trunks of the tree Yucca (*Y. arborescens*) which had been ascended by a small desert mammal known as the wood rat (*Neotoma Mexicana*). The wood rats cut off the leaves of the Yucca at the base and thus form a spiral groove or ladder around the trunk. The leaves are used by the rats in the construction of their bulky nests which are commonly made up of spiny materials such as sharp splinters of rock, parts of cactus, leaves of Yuccas, branches of spiny desert shrubs and the like. The heaps of rubbish thus formed over the mouths of their burrows constitute a protection against coyotes and other enemies." This wood rat which is the only animal known to ascend the Yucca trunk, may not have as its main object the fruits to be found there. Dr. Merriam informs me that he has found freshly cut leaves at a time when there were no fruits on the plant. They may merely desire the leaves for their nests or may feed on the tissue of the base of the leaf.

The habit of certain of the cored species of *Sarcoyuccas* in dropping their fruits as soon as mature, which was discussed in the early part of this paper, must be remembered here. In these species, *baccata*, *valida*, and *Guatemalensis*, the reflexed leaves could hardly be considered as a protection to the fruits when these, as soon as they mature and become desirable, drop to the ground, — as we suspect in order to be gathered and eaten by certain of those animals which cannot climb the trunk, the core serving to protect

* Merriam, C. Hart, "Notes on the Geographical and Vertical Distribution of Cactuses, Yuccas and Agave in the Deserts of Southern California * * * etc.," l. c., p. 353.

the seeds. In *aloifolia*, where there is no core and the fruits remain persistent until they dry up, it may be that the protection afforded the fruits by the reflexed leaves is of considerable importance. All indications here point to the fruit as being particularly modified for dissemination by small birds. The sweet tender pulp would be a tempting morsel for many animals, and not having a protecting core many of the seeds might be destroyed.

The service which the reflexed leaves render in seed dissemination has already been discussed. I would not consider, however, that this function has primarily had any influence in leading to the development of the habit of leaf reflexion. I am not disposed either to look upon the protection which this habit affords the fruits of certain species as being the primary cause. I am inclined to the opinion that the primary cause must be sought for among the intricate relations between light and growth, coupled with the habit of growth of the plant, the reflexion being necessary to permit the accumulated seeds and rubbish caught by the erect leaves to fall to the ground. It may be merely the common habit shown by certain Monocotyledonous plants of this nature, such as palms which have tufted tops at the ends of tall trunks. The lower leaves of such trees gradually assume a reflexed position, evidently due to the pressure exerted by the development of other leaves above and an attempt to assume the most advantageous position in relation to the light. The old leaves of palms gradually become strongly reflexed and ultimately dry up and break off, their bases frequently remaining attached for a time and then rotting away, leaving a smooth trunk. If this habit were coupled with the development of phytomeroids such as occur in *Y. aloifolia* one might reasonably expect this leaf reflexion to become periodic, corresponding to the phytomeroids.

The *Clistoyuccas*, having dry indehiscent fruits, include two species, *gloriosa* and *brevifolia*. Of the dissemination of *gloriosa* apparently nothing is known. While this plant

is common in cultivation it very seldom fruits and has not been much studied.

Brevifolia differs from other known species in having a very thick exocarp similar to that of *aloifolia* but which on maturing becomes dry and spongy instead of pulpy. What is known of the dissemination of this species is from the observations of Dr. Trelease:* "The fruits of this species fall quickly after ripening either by a distinct disarticulation or because of the brittleness of the pericarp at the base, and their rounded form and very light specific gravity render them well-developed 'tumble fruits' and point to their dissemination over the dry sands of the desert by aid of the strong winds which prevail there, the seeds being liberated ultimately by the breaking of the fragile pericarp."

The *Chaenoyuccas* or capsular species, which have dry erect capsules and light, strongly compressed seeds, are typical wind-disseminated plants. The capsules open by a gradual septicidal dehiscence from above downward and by a dehiscence for a certain distance from the top through the backs of the carpels (Plate 47, fig. 5).

The seeds are very thin and flat, ranging in thickness from .5 to 1.5 millimeters, and have a very slight wing (Plate 47, fig. 6), a flying apparatus of the simplest kind similar to that in Iris, Tulipa and Agave.† They are arranged in six rows and are gradually sifted out of the erect capsules by the shaking of the fruit cluster by the wind or animals and by the wind dipping into the open top of the cells. The device is thus to secure the gradual scattering of the seeds, a few at a time by gusts of wind, the wind serving to carry the seeds for some distance.

The peduncle of the capsular species is usually quite long, serving to raise the fruit cluster free of obstruction to some height above the surrounding vegetation. *Filamentosa* and *glauca*, the most widely known capsular Yuccas,

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* † Trelease, Wm., "Further Studies of Yuccas and their Pollination," l. c., p. 224.

† Hildebrand, "Verbreitungsmittel der Pflanzen," p. 16.

grow on prairies or in open fields, and *elata* is a plant which frequents the open mesas of the Arizona plains. Those Yuccas which are dependent on the wind for their dissemination apparently always grow in open places where the wind has free action upon them. The Sarcoyuccas on the contrary frequently grow in wooded areas, mountainous districts, etc. *Aloifolia* sometimes grows in dense hammocks. *Macrocarpa*, Prof. Toumey reports as a strictly mountainous plant, frequenting shady cañons in Arizona.* Habitat evidently has important connection with the methods of dissemination employed by the various species.

The peduncles in *filamentosa*, some time after the fruits have ripened, very commonly rot at the base and fall. This serves to empty the few seeds which may remain in the capsules at some distance from the parent plant. The peduncles in this species vary, in Florida, from 3 to 12 feet in length.

SUMMARY.

In Yuccas the three types of fruits, characterizing the different groups, correspond to three types of dissemination.

The *Sarcoyuccas*, having fleshy fruits, are probably intended for dissemination by fruit-eating animals.

In the fleshy fruits of *baccata*, *valida* and *Guatemalensis* the seeds are surrounded by a papery core similar to that of the apple. The fruits of these species drop early, probably as soon as mature. This seems to be a device to aid in their dissemination. They are probably gathered by small mammals that eat the pulp, the seeds, which are protected by the core, being discarded.

The fruit of *aloifolia*, which is fleshy throughout and persistent, is principally disseminated by the mocking bird. This is accomplished by the bird swallowing the seeds while eating the pulp. The seeds remain uninjured

* Toumey, J. W., "Notes on the Tree Flora of the Chiricahua Mountains." Garden and Forest, VIII. (Jan. 16, 1895), p. 22.

and are evacuated in good condition for germination. Many seeds are also scattered by being twitched to some distance by the bird, in freeing its bill from the adhering pulp and seeds. A tame mocking bird swallowed and evacuated 51 seeds in 4 hours. A number of these were afterwards germinated.

The trunk of *aloifolia* is prolonged by the lateral branch or branches which spring from near the base of the old fruit cluster. This branch prolongs the trunk and in turn bears an inflorescence and fruit, about two years being required usually to complete the period of development. The *aloifolia* trunk in its development may thus be divided into definite stages or segments, which in the lack of a term to designate them are here called *phytomeroids*. The lateral branch which continues the stem starts to develop about the time that the fleshy fruits begin to dry up. At about the same time the erect leaves of the phytomeroid to which the fruit cluster belongs begin to reflex, and soon come to point strongly downward. The reflexed persistent leaves of the older phytomeroids become closely appressed against the stem and, pointing downward like a series of bayonets, prevent small mammals from climbing the trunk. The reflexed leaves aid as a secondary method of dissemination. Seeds and dry fruits falling on these are directed or thrown outward so that they fall at a distance of a meter or so from the parent plant.

Old fruit clusters of *aloifolia*, after the fruits have passed the stage for bird eating by drying up, are cut off by the larvæ of *Prodoxus decipiens*. The leaves of the phytomeroid to which these fruit clusters belong, have by this time become reflexed and thus do not prevent the fall of the cluster but direct it outward away from the parent plant.

The reflexed leaves by preventing animals from climbing the trunk also serve to protect the fruits from the ravages of those animals that might injure the seeds.

The protection of the fruits and aid in seed dissemina-

tion are not thought to be the primary factors leading to the development of the habit of leaf reflexion.

The primary cause which leads to the development of this habit is probably to be found in the relations between light and growth, and the necessity for some such habit to free the plant from rubbish which becomes lodged in the erect crown of rigid leaves.

Yucca brevifolia, illustrating the *Clistoyuccas*, is unique in having a light spongy fruit which falls when mature and is blown about as a rolling fruit, gradually breaking up and dropping the seeds.

The capsular Yuccas, like *filamentosa* and *glauca*, are developed for wind dissemination. They have very thin light seeds which are gradually sifted out of the capsules and blown to some distance by the wind.

The wind disseminated Yuccas grow in open places where the wind can have free action upon them.

The rotting off at the base and falling of the old fruit stems of *filamentosa* serves finally to throw out all seeds which remain in the capsules.

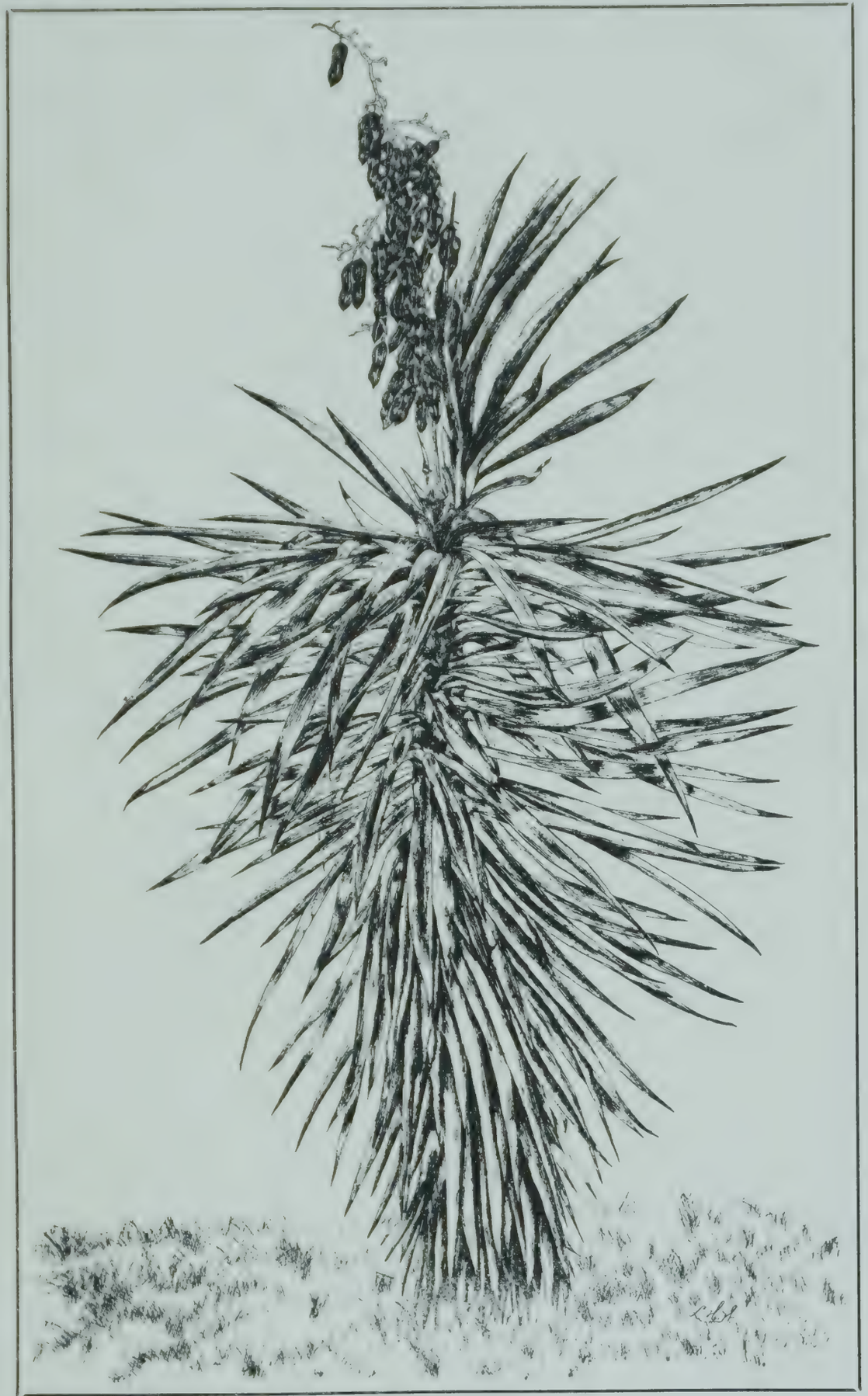
Eustis, Florida. January 12th, 1895.

EXPLANATION OF PLATES ILLUSTRATING THE DISSEMINATION OF YUCCA.

Plate 45.— *Yucca aloifolia*, with lateral branch developing from near the base of the peduncle. The leaves of the phytomeroid which bore the inflorescence have begun to reflex.—Drawn by Mrs. Webber, from a photograph of a plant at Bartow, Florida, January 24, 1894.

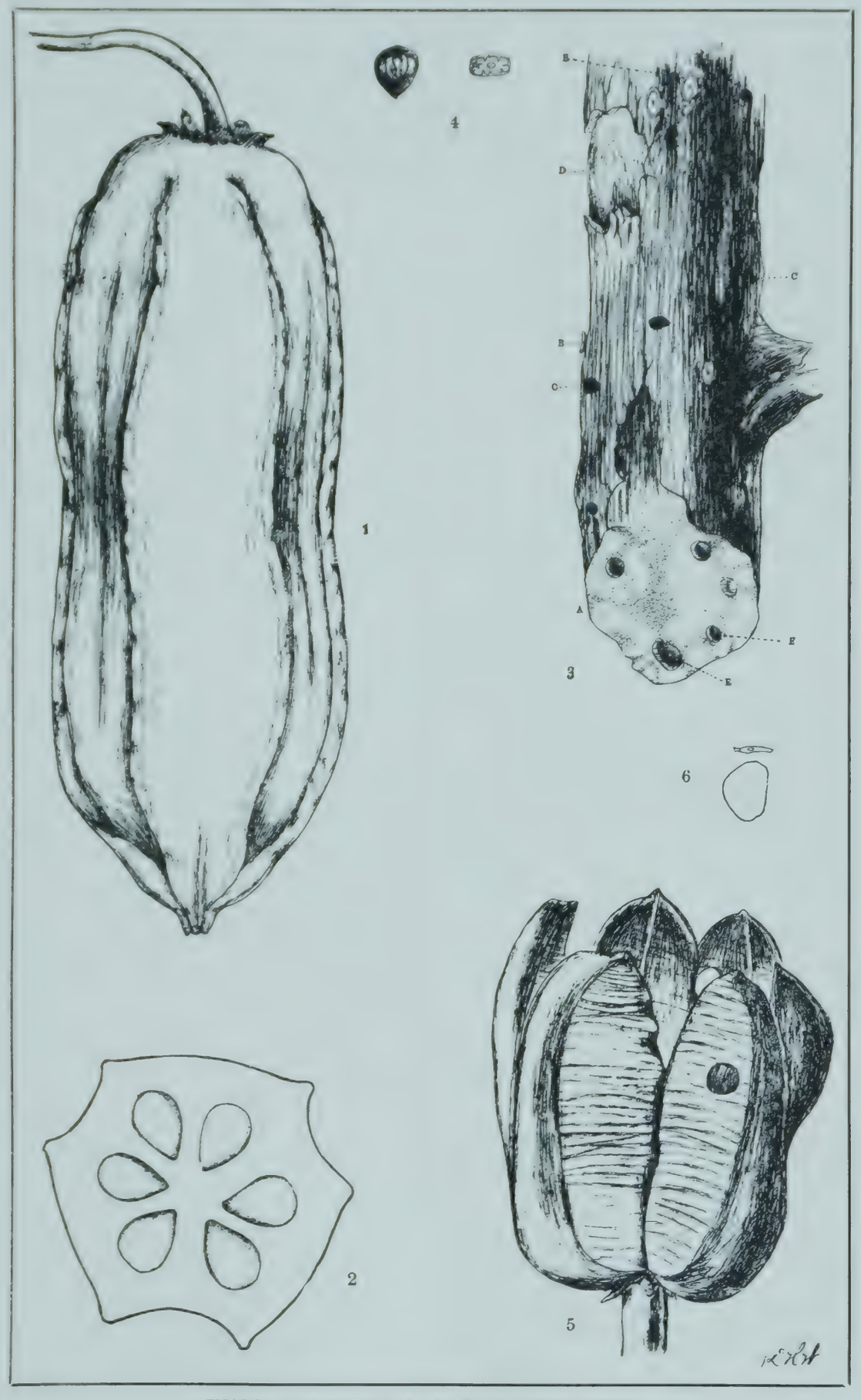
Plate 46. — *Y. aloifolia*, with lateral branches starting at the base of the old peduncles, and the leaves of the upper phytomeroid starting to reflex.—From a photograph of plants on Anastatia Island, Fla., Jan. 23, 1895.

Plate 47.—Fig. 1. Ripe fruit of *Y. aloifolia* — Fig. 2. Cross section of *aloifolia* fruit. — Fig. 3. Basal end of old peduncle of *Y. aloifolia* cut off at *a* by *Prodoxus decipiens*; *bb*, scars resulting from oviposition of *Prodoxus* female; *cc*, perforations made by the chrysalis of *Prodoxus* in issuing; *d*, portion of the epidermis cut away by the burrowing of *Prodoxus*; *ee*, tunnels in the tissue made by *Prodoxus* larvæ.— Fig 4. *Y. aloifolia* seed, and cross section of seed showing ruminated endosperm.— Fig. 5. Capsule of *Y. filamentosa*. — Fig. 6. *Y. filamentosa* seed, and cross section. — All nat. size, drawn from nature by Mrs. Webber.



YUCCA ALOIFOLIA.

YUCCA ALOIFOLIA.



YUCCA ALOIFOLIA AND FILAMENTOSA.

NOTES AND OBSERVATIONS
ON NEW OR LITTLE KNOWN SPECIES.

BY JARED G. SMITH.

SIDA PALMERI, Baker?

Slender, erect or ascending perennial, 4 to 6 dm. high, sparingly branched from the base, the stems cinereous stellate pubescent; leaves remote, subcordate at the base, obtuse at the apex, from ovate-triangular to triangular oblong, usually with rounded basal lobes, serrate or entire, sparsely stellate-pubescent above, densely stellate-tomentose below, the blade usually longer than the petiole; stipules subulate; peduncles slender, axillary, 3 to 5 cm. long, geniculate above; calyx tube terete; sepals ovate, abruptly acute, stellate-canescent, about 4 mm. long, a third as long as the yellow or purple petals; carpels 7 to 9, dehiscent, sparsely pubescent on the back, the sides latticed; seed obliquely obovate-triangular, glandular punctate, the hilum obovate, smooth. Collected by G. C. Nealley, near Corpus Christi, Texas, in the summer of 1894, and reported by him as being rare.— Plate 48.

This form approaches *S. Palmeri*, Baker, Journ. of Botany, **30**, 295 (1892), a species of section *Malvinda*, founded on Palmer's No. 1038, and may not be distinct from it. I have not had the opportunity of examining authentic specimens, but Nealley's plant does not fully agree with Baker's description.

FUGOSIA DRUMMONDII, Gray. Pl. Wright. **1**, 23 (1852).

This plant, of which habit sketch and detail drawings are appended, was collected by G. C. Nealley, near Corpus Christi, Texas, in 1894. The locality is re-established

after a lapse of sixty years, the plant not having been found in the United States since Drummond's original collection in 1834. The specimens agree with the published descriptions and with herbarium material of the same species from South America.—Plate 49.

SEDUM TEXANUM, n. sp.

Herbaceous perennial; glabrous, ascending, 1.5 to 2 dm. high, cespitose, sparingly branched from near the base; leaves sparse, thick fleshy, obovate to ovate lanceolate, obtuse or mostly acute or acuminate, broad at the base, sessile, 2 to 2.5 cm. long; flowers sessile or short pedicelled, solitary or two or three together, forming a sub-secund raceme, or paniculately branched in the larger specimens, rather remotely flowered below; sepals oblong, acute; petals 5, rosy yellow, narrowly oblong, thickened and apiculate at the apex, one-half longer than the sepals; scales minute, truncate; stamens 10, shorter than the petals, the filaments flattened; anthers bright yellow; carpels 5, inflated, many seeded, with a slender beak tipped by the very short persistent style, dehiscent down the ventral suture. Collected by G. C. Nealley, in flower, the last week in October, 1894, growing in the chapparal near Corpus Christi, Texas. It is most closely related to *S. Wrightii*, Gray, but differs in the form of the inflorescence and in the much larger leaves. The type specimen is in the herbarium of the Missouri Botanical Garden.—Plate 50.

ELYTRARIA BROMOIDES, Oersted.

This and STENANDRIUM DULCE, Nees, are two interesting little Texan plants collected near Corpus Christi by Mr. Nealley. Habit sketches and detail drawings of flower and fruit are given in plate 51.

ZEPHRYANTHES PULCHELLA, n. sp.

Bulb globose, 1 to 2 cm. in diameter, covered with dark brown tunics; neck 3 to 4 cm. long; leaves 3 or 4, appear-

ing with the flower, 1 to 2 mm. wide, 1.5 to 2.5 dm. long; scape slender, 1.5 to 2 dm. long; flower solitary, erect; spathe 2 to 2.5 cm. long, tubular for half its length, slightly exceeding the pedicel, entire at the apex; perianth erect, 2 cm. long, the segments oblanceolate, acute, bright yellow; tube 5 mm. long; stamens inserted at the throat, about half as long as the perianth segments; style equaling the stamens; stigma capitate, 3-lobed. Collected at Corpus Christi, Texas, summer of 1894, by G. C. Nealley. It is intermediate between *Z. Texana*, Herb. and *Z. Longifolia*, Hemsl. For purposes of comparison I have figured flowers of these latter species on the same plate. The pedicel length is a very constant character in all the herbarium specimens of the two older species which I have examined, and it is one of the principal specific characters used by Baker in his monograph of the Amaryllidaceae. Hence, I have considered it best to separate out this material as a new species.—Plate 52.

SAGITTARIA.

Since publishing the monograph of the North American species of Sagittaria and Lophotocarpus, I have received material of the following new species of Sagittaria from Florida.

§§§ *Integrifoliae.*

+ + + Achenium obovate, with a short lateral beak; filament dilated at the base, pubescent; bracts connate, glabrous.

S. ISOETIFORMIS, n. sp.

Monoecious, 1 dm. high; leaves slender, terete throughout, or dilating into a short linear blade 1 to 2 mm. wide; scape simple, slender, erect, equaling the leaves, with mostly a single verticil; bracts ovate, acute, 2 to 3 mm. long, connate; fertile pedicels shorter than the sterile, very slender, 15 to 18 mm. long; sterile pedicels filiform, 2 to 3 cm. long; stamens about 9; anthers equaling the filaments; achenium about 1 mm. long, dorsally crested, with an arched

lateral wing, and with 2 pairs of subepidermal resin passages; fruiting head small, 6 mm. in diameter; flowers white, 12 to 14 mm. across. Only 1 or 2 flowers fertile. Growing in tufts at the nodes of very slender stolons, in water 3 to 10 cm. deep. Collected at Eustis, Lake Co., Florida, March 22, 1894, by Geo. V. Nash, and by A. S. Hitchcock in July. It is common along the sandy lake margins and forms quite extensive patches in the shallow water, its slender interlacing stolons bearing tufts of leaves, and rooting at the nodes. It is more closely related to *S. graminea*, Michx. than to any other species. In the artificial key to the genus it should be inserted after *S. macrocarpa*, from which it is easily separated by the smaller achenium. The type is in the Herbarium of the Missouri Botanical Garden.— Plate 53.

Eragrostis sporoboloides, Smith and Bush, n. sp.

Tall perennial; culms 5 to 7 dm. high, erect, simple or branching from the base; sheaths longer than the internodes, pilose, especially at the throat; leaves soft, flat, becoming involute and filiform above, 5 to 8 mm. wide, 4 to 6 dm. long, scabrous on the upper surface, smooth below; panicle oblong, not emergent from the upper sheath, half as long as the culm; branches of the panicle capillary, single or in pairs, minutely scabrous; spikelets 2.5 mm. long, 2 or 3 flowered, on scabrous capillary pedicels 1 to 3 cm. long; empty glumes one-nerved, ovate-lanceolate, acute, scabrous on the keel, two-thirds as long as the lowest floret; flowering glume ovate, acute, 3-nerved, the nerves scabrous above; caryopsis not seen. Collected at Sapulpa, Indian Territory, July, 1894, by B. F. Bush. This grass is closely related to *Eragrostis capillaris*, Nees, but is perennial, and has much longer and wider leaves. Immature specimens appear at first sight only one-flowered, and might be mistaken for excessively long leaved forms of *Sporobolus asperifolius* Thurb., a resemblance which is heightened by the very pilose sheaths; hence the specific

name *sporoboloides*. The type specimens are in the herbarium of the Missouri Botanical Garden.—Plate 54.

ERAGROSTIS GRANDIFLORA, Smith and Bush, n. sp.

Perennial; culms simple, 1 meter high, the nodes much elongated; panicle large, occupying more than half the culm, 6 dm. long; panicle branches slender, ascending, 12 to 15 cm. long, the lower pilose in the axils; empty glumes lanceolate, very acute, a little shorter than the lowest florets, 2.5 mm. long, the first one-, the second three-nerved; rachilla glabrous, articulate; spikelet 10 to 20 flowered, 1 to 2 cm. long, longer than the scabrous capillary pedicels; flowering glume 3 mm. long, ovate, acute, glabrous, a little longer than the palet; caryopsis 1 mm. long, truncate at each end, furrowed; leaves ample, 3 or 4 dm. or more long, 7 to 10 mm. wide, attenuate and filiform at the apex, scabrous above and on the margins; sheaths smooth or hirsute above, and pilose at the throat. This species is most closely related to *Eragrostis tenuis*, Gray, but is easily distinguished by its elongated spikelets. Collected at Sapulpa, Indian Territory, Oct. 1, 1894, by B. F. Bush. Type specimen in the herbarium of the Missouri Botanical Garden.— Plate 55.

ERAGROSTIS BEYRICHII, n. sp.

Low cespitose perennial, 1 to 2 dm. high; culms geniculate below, ascending or erect, much branched from the base, smooth, terete, glabrous, mostly with 3 nodes; sheath striate, smooth, shorter than the internode, ciliate at the throat; ligule very short; leaves soft, smooth or very minutely scabrous above, linear, 6 to 8 or 15 cm. long, 1.5 to 2 mm. wide, soon involute and filiform, attenuate above, usually much shorter than the culms; spikelets sessile or short pedicelled and densely fasciculate in an interrupted spike-like or capitate panicle, linear-oblong, strongly compressed; 15 to 40 flowered, mostly 10 to 15 or rarely 25 mm. long, 5 mm. broad; panicle branches single,

ciliate in the axils; empty glumes lanceolate acuminate, over half as long as the lowest florets, the first one-, the second three-nerved, tinged with purple; flowering glume and palet pale straw color; flowering glume lanceolate acuminate, 3-nerved, 4 mm. long, keel and lateral nerves scabrous; palet oblong, $\frac{2}{3}$ as long, 2-nerved, scabrous on the margins and nerves below, erose at the apex; caryopsis terete, linear, 1 mm. long. This species is dedicated to Beyrich, who first collected it in Arkansas in 1834. Specimens have also been examined from Dallas, Texas, collected by Reverchon, 499, 1874, and by Prof. Geo. W. Letterman, July 25, 1881. It is most closely related to *Eragrostis oxylepis*, Torr., but differs in habit and in the very acute flowering glumes and narrow spikelets. Type in the Bernhardi Herbarium.— Plate 56.

ERAGROSTIS SECUNDIFLORA, Presl, Reliq. Haenk. **1**, 276 (1830).

A specimen of this, collected by Haenke in Mexico, is in the Bernhardi Herbarium. It is identical with *Eragrostis oxylepis*, Torr., Rep. Bot. Whipple Exped. 156 (1857); *Poa interrupta*, Nutt. Trans. Amer. Phil. Soc. (n. ser.) **5**, 146 (1837), not Lam. Illustr. **1**, 185 (1791); *Eragrostis interrupta* (Nutt.), Trelease, Ann. Rep. Geol. Surv. Ark. **6**, 237 (1888), not Beauv. Agrost. 71 (1812); and *Eragrostis Verae-Crucis*, Rupr. Bull. Acad. Brux. **9**, reimp. 9 (1842). I have examined specimens as follows: — Mexico: Haenke, without locality or date; and Liebmann 538 (*E. Verae-Crucis*, Rupr.), Pochutla, La Galera, Oct., 1842. New Mexico: Fendler 913, 1847. Texas: Drummond 228, 321 and 325, 1832–1834; Lindheimer 32, Galveston, April 1843, 734, 735, 1847, and Granite Hills of the Llano, 464, Oct., 1847; Ravenel, Indianola, May 3, 1869; Pringle 1969, July 28, 1888; Pammel, Brazos Co., Aug., 1888; Letterman, Texarkana, Oct. 18, 1894; Heller 1802, Corpus Christi, May 28–31, 1894. Indian Territory: Torrey, Marcy's Expedition, Wichita Mts. 1852, in the Buckley Herbarium;

Bush 823, 824, Arkansas, July 23, 1894. Arkansas: Engelmann, Arkansas R. below Little Rock, July, 1835. Mississippi: Seymour 35, (Tracey Coll.) Starkville, Sept., 1891. Florida: Dr. Leavenworth, "Gulf of Mexico." Good Plates are given by Torrey: Marcy's Red Riv. of Louis. Exp., plate 19 (1854); and by Dr. Vasey: Grasses of the Southwest, Part 2, plate 48 (1891).

The Bernhardi Herbarium contains a large number of Haenke's grasses, the labels of which are almost certainly in Presl's handwriting. These have not all been separated out, but when they are, further notes may be made concerning them.

EXPLANATION OF PLATES.

Plate 48. *Sida Palmeri*, Baker (?) — Habit sketch, half size; fruit, × 5, seed, × 7.

Plate 49. *Fugosia Drummondii*, Gray.— Habit sketch and section of flower, natural size.

Plate 50. *Sedum Texanum*, J. G. Smith.— Habit sketch, natural size; flower and isolated petal, × 3; apex of petal, × 6.

Plate 51. *Elytraria bromoides*, Oerst.— 1, habit sketch, natural size; 2, bracts and calyx, × 3; 3, corolla × 2; 4, capsule, × 5; 5, stamen, × 5. *Stenandrium dulce*, Nees.— 6, habit sketch, natural size; 7, corolla × 2; 8, stamens, × 5; 9, calyx, × 3; 10, pistil, × 5; 11, capsule and seeds, × 3.

Plate 52. *Zephryanthes pulchella*, J. G. Smith.—1, habit sketch, natural size; 2 and 3, style and stamen, × 3. *Z. longifolia* Hemsl.—4, flower and spathe, natural size; 5 and 6, stamen and style, × 3. *Z. Texana* Herb.— 7, flower and spathe, natural size; 8 and 9, stamen and style, × 3.

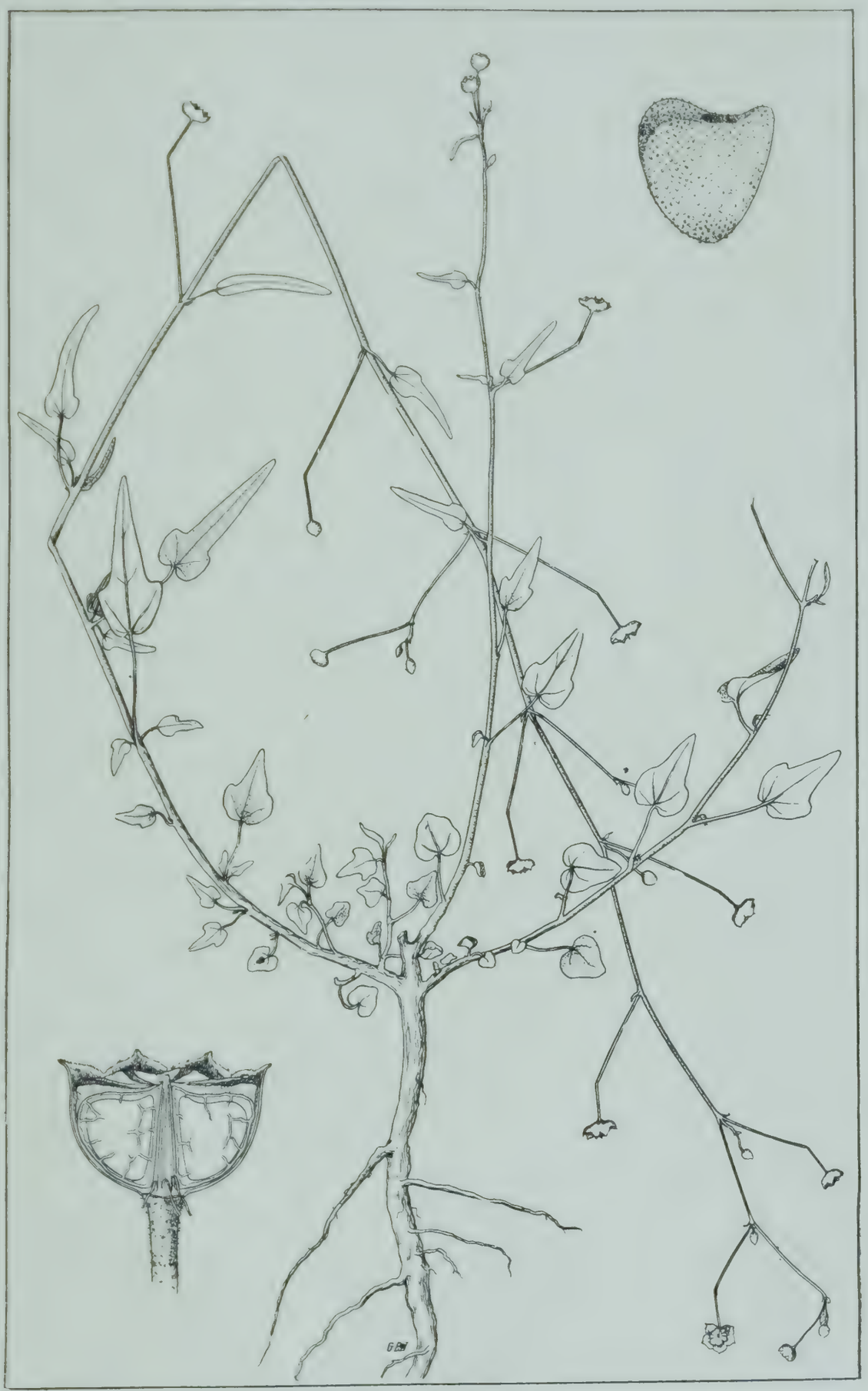
Plate 53. *Sagittaria isoetiformis*, J. G. Smith.— Habit sketch, natural size; stamen; and cross section, dorsal and side views of achenium, × 10; *a* cross section of petiole, × 30.

Plate 54. *Eragrostis sporoboloides*, J. G. Smith and B. F. Bush. —Habit sketch, one-half natural size; spikelet and flowering glume, × 5.

Plate 55. *Eragrostis grandiflora*, J. G. Smith and B. F. Bush. — Habit sketch, one-half natural size; offshoot from base of plant with immature spikelets, natural size; base of spikelet, flowering glume and palet, × 5; caryopsis, × 15.

Plate 56. *Eragrostis Beyrichii*, J. G. Smith.— Habit sketch, one-half natural size; base of spikelet, and flowering glume, × 4; 1, empty glumes, × 4; 2, face and side view of palet, × 4; caryopsis × 15.

The plates were prepared from drawings made by Miss Grace E. Johnson, from specimens preserved in the Herbarium of the Missouri Botanical Garden.



SIDA PALMERI?

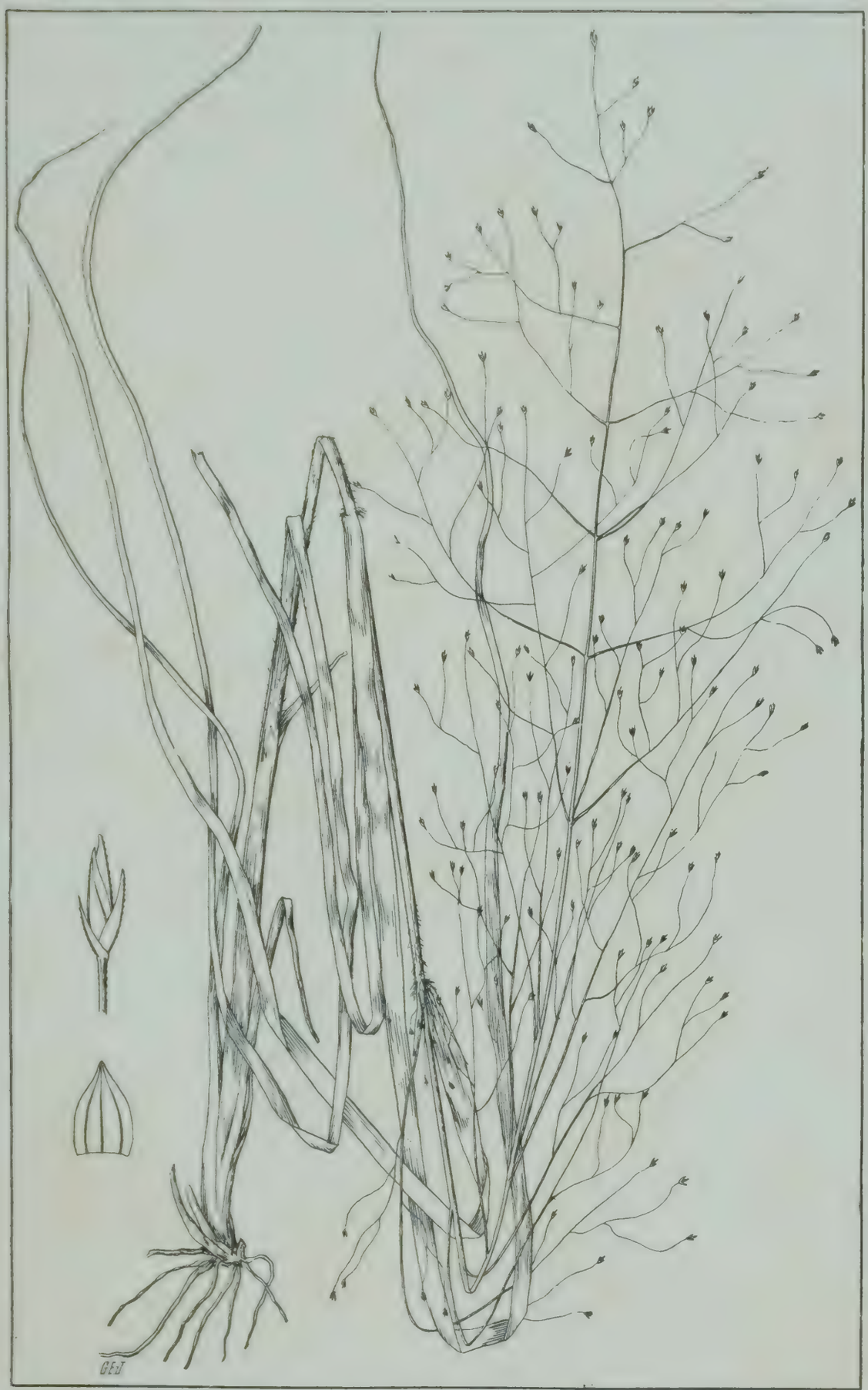
FUGOSIA DRUMMONDII.

SEDUM TEXANUM.

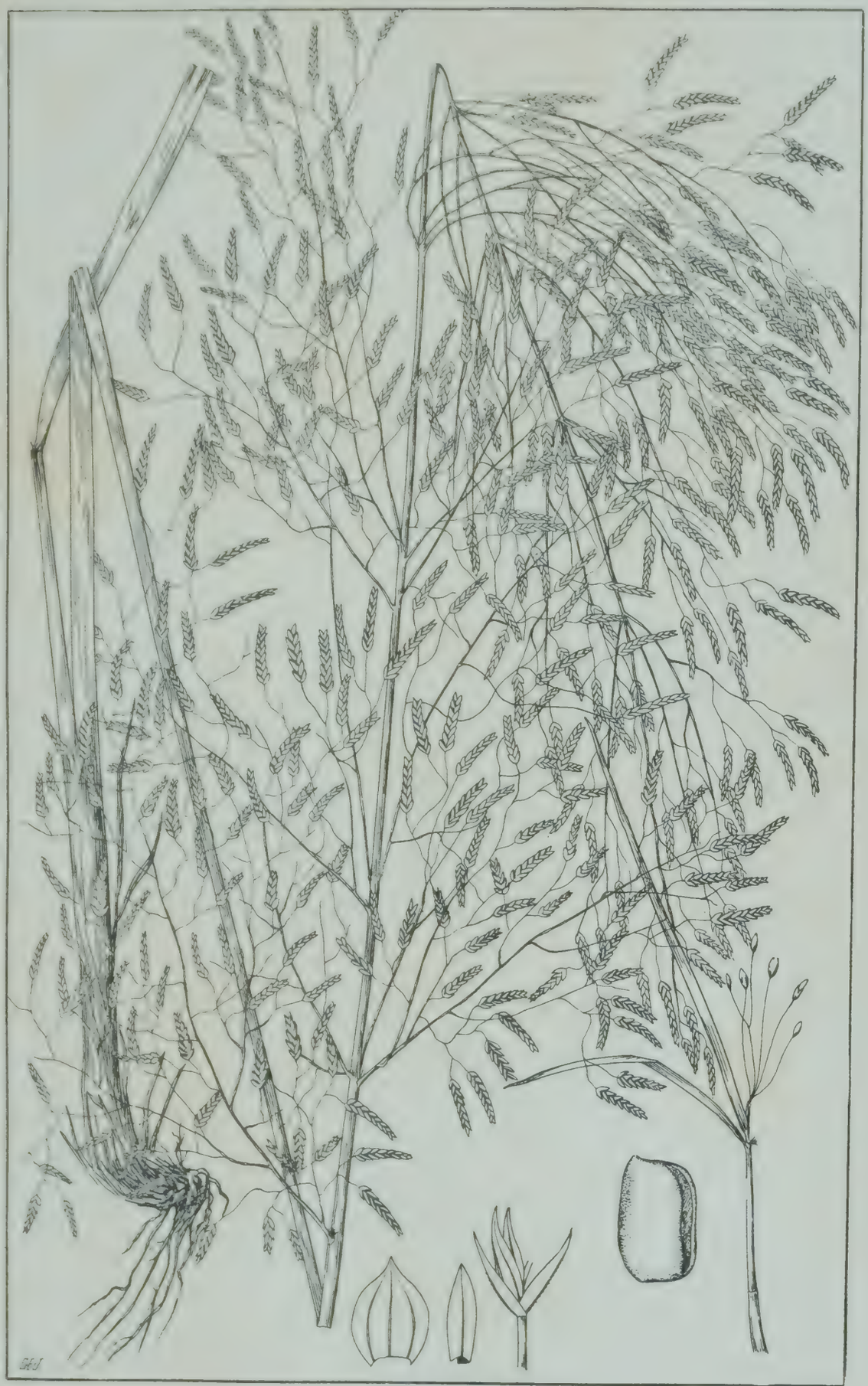
ELYTRARIA AND STENANDRIUM.

ZEPHYRANTHES.

SAGITTARIA ISOETIFORMIS.



ERAGROSTIS SPOROBOLOIDES.



ERAGROSTIS GRANDIFLORA.

ERAGROSTIS BEYRICHII.

NOTES ON THE MOUND FLORA OF ATCHISON COUNTY, MISSOURI.

BY B. F. BUSH.

Having concluded that Atchison County, Missouri, on account of its extreme northwestern position, would prove a fertile field for botanizing, I consulted with Dr. Trelease upon the advisability of making a thorough investigation of that part of the State, and he very generously placed me in shape to begin the work.

About the middle of August, 1893, I made my first trip to that place, and was struck at once by the remarkable line of loess mounds running parallel with the Missouri River in Missouri, from Hamburg in Iowa, down to a few miles south of Saint Joseph, Missouri, where the last bald-headed mound appears.

These singular mounds are evidently the result of the glacial period, when great masses of ice were borne toward the equator, until they were stranded along the low rocky bluffs of the Missouri River, and as they melted, the mud and debris settled to the bottom and thus formed these mounds.

These mounds are very irregular and jagged, running in straight lines, or else in fantastic loops and curves, often abruptly terminating in a very high perpendicular wall, which is almost unaffected by the action of the weather: or commonly descending gently to the level bottom which surrounds all sides except on the east.

At a distance these mounds appear to be terraced, as if furrowed by the plow, but on a closer examination it is revealed that the apparent terraces are trails made by cattle, which are nearly always to be found grazing on them. These trails are about four feet apart and either follow a horizontal line around the mounds, or else gradually incline

upward to the top of them, and a well defined trail leads from the top of one mound down the side and along the low backbone to the side and top of the next mound, and so on to all the mounds.

I have found these trails of considerable advantage in climbing over and around the mounds, and in going from one mound to another, and I have never seen one isolated mound in Atchison County.

The south and west sides are those which are steep and precipitous, but sometimes they descend gradually to the bottom lands at their bases. The north and east sides are usually descending and are covered with a short thick growth of trees and shrubs near their bases, but which does not rise as high up on the north side as on the east, as it sometimes reaches quite to the top on the latter.

The texture of the soil is a thin, slightly sandy loess, very compact and hard, so much so, that names carved in the face of the steep sides endure for many years. The fertility of the soil is very low and supports only such plants as will thrive in similar conditions, being covered with a short growth of grasses, such as Bouteloua hirsuta, B. oligostachya and Sporobolus airoides.

There is a belt of heavy timber back of the mounds, which averages about one mile in width, and which is somewhat lower than the mounds, and back of this is a high rolling prairie, which is considerably lower than the mounds. Between the mounds and the Missouri River is an extremely fertile gombo bottom-prairie which is sometimes several miles in width, and often not a mile wide, which has a flora very similar to the general Missouri River bottom flora, except that a few of the peculiar species of the mounds are here present and should not be considered as characteristic of it.

Where the south and west sides are steep and precipitous, there are to be found in abundance such plants as Yucca glauca, Gaura coccinea, Psoralea argophylla, Meriola serrulata and Sporobolus airoides; where they descend gradu-

ally to the bottom below, such plants as Pentstemon grandiflorus, Astragalus lotiflorus and Parosela enneandra are found. On the north there are usually pockets running up the sides of the mounds which are generally covered with dwarfed trees and shrubs, principally Corylus Americana, Prunus Virginiana, Ostrya Virginica, Rhus glabra, and Salix humilis.

The tops of these mounds are the most peculiar feature of the whole country, for they present from a distance a very much denuded appearance, as if entirely devoid of vegetation. They vary considerably in height, some not being one-third as high as the most elevated, and one of the chain is said to be the highest point in the State, and no doubt to this great elevation is due their peculiar flora.

The characteristic species of these mounds are Pentstemon grandiflorus, Spiesia Lamberti, Castilleja sessiliflora, Psoralea argophylla, Gaura coccinea, Glycyrrhiza lepidota, Yucca glauca, Meriola serrulata, Sporobolus airoides, Anemone cylindrica, Lacinaria punctata, Bouteloua hirsuta, B. oligostachya, Astragalus lotiflorus, Gerardia aspera, Parosela enneandra, Lithospermum angustifolium, Lygodesmia juncea, Lactuca pulchella, Onosmodium molle, and Houstonia angustifolia, these being the predominant plants, and not occurring in abundance elsewhere in the State.

The list here appended is based on specimens now in the Herbarium of the Missouri Botanical Garden which were also included in the sets distributed in 1893.

ANEMONE CYLINDRICA A. Gray.

Common on the tops of the mounds in bare ground: commonly with several peduncles involucellate in the middle. (Watson No. 3.)

ANEMONE VIRGINIANA L.

Common along the bases of the mounds, and in the hazel thickets. A. Canadensis L. (Watson No. 4), was abundant in the bottom just below. (Watson No. 5.)

DELPHINIUM CAROLINIANUM Walt.

Common on the tops of all the mounds. The pistils are commonly from three to seven, as I have noticed in the plants of Jackson County, Missouri. (Watson No. 8.)

ACTAEA ALBA (L.) Mill.

Rarely seen on the wooded eastern slopes of the mounds. (Watson No. 9.)

CLEOME SERRULATA Pursh.

Abundant on the lower part of the mounds. Has a very fetid odor, on account of which it is called Stinking Clover by the country people. (Watson No. 16.)

VIOLA PEDATIFIDA Don.

Common all over the bare parts of the mounds. V. obliqua Hill (Watson No. 21), was common in the woods on the east of the mounds. (Watson No. 19.)

VIOLA PALMATA L.

Very common along the bases of the mounds. (Watson No. 20.)

HYPERICUM ASCYRON L.

On the northern sides of several of the mounds. At one mound, I estimated that there were between ten and fifteen thousand plants in one patch, about four miles northeast of Watson. (Watson No. 37.)

LINUM SULCATUM Ridd.

On the bare tops and sides of the mounds, usually with Gerardia aspera Dougl., which it not a little resembles. (Watson No. 42.)

CEANOTHUS OVATUS Desf.

Very common on the sides of the mounds, and appearing quite distinct from the next in appearance and mode of growth. (Watson No. 120.)

CEANOTHUS OVATUS PUBESCENS T. & G.

Also quite common in same situations as the foregoing. (Watson No. 121.)

POLYGALA VERTICILLATA L.

Quite common on the bare parts of the mounds. (Watson No. 184.)

TRIFOLIUM REFLEXUM L.

Common over most parts of the mounds in bare ground. (Watson No. 187.)

PSORALEA ARGOPHYLLA Pursh.

Abundant on the steep precipitous faces of the mounds. One of the most striking species of the whole mound flora. (Watson No. 211.)

AMORPHA CANESCENS Pursh.

Common on the sides of the mounds. Specimens nearly two meters in height were observed at several places. (Watson No. 217.)

PAROSELA ENNEANDRA (Nutt.) Britton.

Abundant on all the mounds, but mostly on the steep sides to the south and west. (Watson No. 220.)

PAROSELA DALEA (L.) Britton.

Common on the lower part of the mounds, and along the backbones, and still more common on the bottom prairie below. (Watson No. 219.)

KUHNISTERA PURPUREA (Vent.) MacM.

Abundant along the backbones connecting the mounds. The heads are all very short-oblong or oval. (Watson No. 222.)

KUHNISTERA CANDIDA (Willd.) Kuntze.

With, and as abundant as the last, and heads also much reduced. (Watson No. 221.)

ASTRAGALUS LOTIFLORUS Hook.

(A. elatiocarpus Sheld. Bull. Minn. Geol. and Nat. Hist. Surv. n. 9: 20. 1894, at least as to forma brachypus. A. lotiflorus formae brachypus and pedunculosus of Gray.)

Abundant on all the gentle slopes and along the backbones of the mounds. When I first collected this species in August, 1893, it was in fruit, with very short or no peduncles, which led Dr. Trelease and myself to place it with the forma brachypus of Gray.

On April 20th, 1894, I collected it again, but this time it was in flower and with very long peduncles. This led me to write Dr. Trelease the statement that the earlier flowers were very long peduncled and infertile, while later on it produced fertile flowers on very short peduncles; for some last year's fruits were still on some plants and no sign of long peduncled fruit had been observed the year before. On June 1st, I again collected the plant and this time it had fruit on both long and short peduncles On July 11th, the long peduncles had mostly dropped off the plants, leaving only the short peduncled fruit. This clearly shows that the species has both long and short-peduncled fruit, and that the formae brachypus and pedunculosus of Gray occur on the same plants. I strongly suspect that the Astragalus elatiocarpus of Sheldon is an entirely different species. (Watson Nos. 198, 199, 200 and 203.)

SPIESIA LAMBERTI (Pursh) Kuntze.

Common on the steep precipitous sides of the highest of the mounds. The roots are exceedingly long and tough, and often are seen hanging over the bluffs from which the earth has crumbled away and left them. (Watson No. 204.)

GLYCYRRHIZA LEPIDOTA Pursh.

Common at the bases of the mounds in bare and somewhat gravelly ground. (Watson No. 205.)

PHASEOLUS PAUCIFLORUS Benth.

Common along the lower part of the mounds, and along the backbones. P. angulosa Missouriensis (Wats.), Britt. (Watson No. 213), was tolerably common in marshy places on the bottom-prairie near the mounds. (Watson No. 212.)

ACUAN ILLINOENSIS (Michx.) Kuntze.

Very common in the bare gravelly ground at the base of the mounds. (Watson No. 214.)

PRUNUS VIRGINIANA L.

Abundant in the pockets on the north sides of the mounds, and is said by the country people to rarely fruit. (Watson No. 243.)

ROSA ARKANSANA Porter.

Abundant on the lower part of the mounds and along the backbones. The receptacles are unusually large, ranging from 12 mm. to 18 mm. in thickness, and the stems of the season are often 25 mm. thick and exceedingly prickly. (Watson No. 246.)

AMELANCHIER CANADENSIS (L.) Medic.

Common on the east sides of the mounds, and in the pockets on the north, often becoming quite arborescent. (Watson No. 313.)

MERIOLA SERRULATA (Nutt.) Walp.

Abundant on the tops and sides of all the mounds. The flowers are from 12 to 15 mm. wide. (Watson No. 330.)

GAURA PARVIFLORA Dougl.

Common near the base of the mounds, and along the backbones. (Watson No. 334.)

GAURA COCCINEA Pursh.

Abundant on the steep faces of most of the mounds. (Watson No. 333.)

SYMPHORICARPUS OCCIDENTALIS Hook.

Abundant at the base of the mounds, and in the pockets on the north sides. S. Symphoricarpus (L.) MacM. (Watson No. 378), which flowers a month or more later, is abundant in the belt of timber to the back of the mounds. (Watson No. 379.)

HOUSTONIA ANGUSTIFOLIA Michx.

Common on the tops and down the sides of the mounds. This is probably the only locality north of the Missouri River where this species is found in the State. (Watson No. 384.)

KUHNIA EUPATORIOIDES L.

Common near the base of the mounds in bare ground. (Watson No. 389.)

LACINARIA PUNCTATA (Hook.) Kuntze.

Common on the steep faces on the south and west sides of the mounds. The other known Missouri stations for this species are: on a high rocky ridge on the prairie west of Lee's Summit in Jackson County, and on a bald knob in Wright County. L. pycnostachya (Michx.) Kuntze (Watson No. 388), is common on the bottom prairie close by the mounds. (Watson No. 387.)

SOLIDAGO SPECIOSA Nutt.

Common on most of the mounds in open ground, but being a much reduced form. (Watson No. 397.)

SOLIDAGO RUPESTRIS Raf.

Abundant on the tops of the mounds. The plants are very much reduced, being only about 3 dm. in height. (Watson No. 398.)

SOLIDAGO NEMORALIS Ait.

Abundant all over the mounds in bare ground, and also very much reduced in size like the two last species. (Watson No. 399.)

SOLIDAGO RIGIDA L.

Common on the bare open places on most of the mounds. S. Canadensis L. (Watson No. 395), and S. ulmifolia Muhl. (Watson No. 396), were common in the belt of timber at the back of the mounds. (Watson No. 400.)

ASTER OBLONGIFOLIUS Nutt.

Common in bare ground mostly all over the mounds. (Watson No. 403.)

ASTER SERICEUS Vent.

Abundant on the tops and over the bare parts of the mounds generally. (Watson No. 404.)

ASTER AZUREUS Lindl.

Common to all the bare parts of the mounds. (Watson No. 405.)

ASTER DRUMMONDII Lindl.

Common on the sides of the mounds in the hazel thickets. (Watson No. 406.)

ASTER LAEVIS L.

Common on the open parts of the mounds. (Watson No. 402.)

ASTER ERICOIDES L.

Common on the lower part of the mounds. (Watson No. 407.)

ASTER AMETHYSTINUS Nutt.

Abundant on nearly all the mounds in bare ground. Specimens were collected that had simple unbranched

stems one meter in height. Very much resembles A. multiflorus Ait., and indeed it may yet prove to be an extreme form of that species, but after a long comparison with authentic specimens, and a critical examination of all the specimens collected, Mr. J. G. Smith and I decided that it must be a form of A. amethystinus. One other Aster, A. paniculatus Lam. (Watson No. 409), was collected on the bottom-prairie near the mounds. (Watson No. 401.)

ANTENNARIA PLANTAGINIFOLIA (L.) Rich.

Common on the bare parts of the mounds. (Watson No. 414.)

SILPHIUM INTEGRIFOLIUM Michx.

Common down the sides of all the mounds. S. laciniatum L. (Watson No. 416), and S. perfoliatum L. (Watson No. 417), were abundant on the bottom-prairie below the mounds. (Watson No. 415.)

HELIOPSIS SCABRA Dunal.

Common along the backbones of the mounds. (Watson No. 418.)

HELIANTHUS MAXIMILIANI Schrad.

Common down the sides and along the backbones of most of the mounds. H. grosse-serratus Martens (Watson No. 420), which it somewhat resembles, is abundant on the bottom-prairie below. Since Maximilian collected the species in Missouri in 1815, it has been found in Wright County, 1884 (Bush), and in Jackson County at Sheffield, 1892 (Bush No. 413). (Watson No. 419.)

ARTEMISIA GNAPHALODES Nutt.

Abundant around the bases of the mounds, and along the backbones. (Watson No. 421.)

CACALIA TUBEROSA Nutt.

Common near the base of the mounds. (Watson No. 422).

CARDUUS UNDULATUS Nutt.

On several mounds about half way up their sides. C. altissimus L. (Watson No. 433), and C. lanceolatus L. (Watson No. 434), were common on the bottom prairie below. (Watson No. 429.)

LYGODESMIA JUNCEA (Pursh) Don.

Abundant all over the mounds, wherever the ground is bare and free of shrubs. (Watson No. 428.)

LACTUCA PULCHELLA (Pursh) D. C.

Common near the bases of nearly all the mounds. Flowers a month earlier than any of our other Lactucas. (Watson No. 427.)

LACTUCA LUDOVICIANA (Nutt.) D. C.

Common with the last species. Several other species, as L. scariola L. (Watson No. 424), L. Canadensis L. (Watson No. 425), and L. sagittaefolia Ell. (Watson No. 423), were common near the mounds on the bottom-prairie. (Watson No. 426.)

ASCLEPIAS VERTICILLATA L.

Abundant on all the bare parts of the mounds. A. Sullivantii Engelm. (Watson No. 436), and A. Syriaca L. (Watson No. 437), were common on the bottom-prairie near the mounds. (Watson No. 435.)

ACERATES VIRIDIFLORA IVESII Britton.

Common on all the mounds in bare ground. (Watson No. 438.)

ACERATES VIRIDIFLORA LINEARIS A. Gray.

Not uncommon with the last. The specific form was not observed in the county. (Watson No. 439.)

LAPPULA LAPPULA (L.) Karst.

Common on nearly all the mounds, but most likely intro-

duced by the cattle which graze over the mounds. (Watson No. 472.)

LITHOSPERMUM CANESCENS (Michx.) Lehm.

Common on the open parts of the mounds. (Watson No. 474.)

LITHOSPERMUM ANGUSTIFOLIUM Michx.

Common on the tops of all the mounds. (Watson No. 473.)

ONOSMODIUM MOLLE Michx.

Common on the sides and along the backbones of the mounds. (Watson No. 475.)

PENTSTEMON GRANDIFLORUS Nutt.

Very common on the sides of the taller mounds, but not observed on the lower ones. (Watson No. 476.)

GERARDIA ASPERA Dougl.

Common on the tops and steep sides of the larger mounds. (Watson No. 479.)

CASTILLEJA SESSILIFLORA Pursh.

Abundant on the sides of nearly all the mounds. (Watson No. 481.)

TEUCRIUM OCCIDENTALE A. Gray.

Common down the sides of all the mounds, and spreading out into the bottom-prairie below, where it becomes abundant. Extends down the Missouri River to Holt County (Corning No. 482), where it is equally abundant, and to Jackson County (Courtney No. 485), where it is uncommon, and it has even been picked up in East Saint Louis by Eggert, but this last may have been introduced by means of hay with which it grew when cut. (Watson No. 483.)

SCUTELLARIA PARVULA Michx.

Common on the sides of most of the mounds. (Watson No. 484.)

EUPHORBIA GLYPTOSPERMA Engelm.

Abundant on the tops of all the taller mounds. (Watson No. 495.)

EUPHORBIA MARGINATA Pursh.

Abundant along the lower part of all the mounds. Called Snow-on-the-Mountain by the country people. E. serpens H. B. K. (Watson No. 497) was abundant on the bottom-prairie below. (Watson No. 496.)

QUERCUS MACROCARPA OLIVAEFORMIS (Michx. f.) A. Gray.

Common in the pockets on the north sides, and in thickets at the bases of the mounds. The growth of the year and the leaves are densely woolly-tomentose, and the trees are from 3 m. to 6 m. in height. (Watson No. 633.)

SALIX HUMILIS Marsh.

Abundant in the pockets on the north sides of all the mounds. (Watson No. 658.)

SISYRINCHIUM BERMUDIANUM L.

Common on the tops of nearly all the mounds. This is what has been called S. angustifolium, and which appears to me to be very distinct from S. Bermudianum, but I bow to the decision of the makers of the new Check List. (Watson No. 671.)

YUCCA GLAUCA Nutt.

Common to all the large mounds, on the steep precipitous sides on the south and west. When observed on June 1st, 1894, it was in full flower, and the Pronuba moth was present in great numbers, and on July 11th, I noticed that there was an abundance of mature fruits, many of which showed the insect punctures plainly. It is called Soap-weed by the

country people, who dig the long saponaceous roots for the purpose of making soap. (Watson No. 672.)

ANDROPOGON SCOPARIUS Michx.

Common along the bases of the mounds. (Watson No. 773.)

ANDROPOGON PROVINCIALIS Lam.

Common with the last species. (Watson No. 774.)

SPOROBOLUS AIROIDES Torr.

Abundant mostly all over the mounds, especially on the steep sides of them. (Watson No. 783.)

BOUTELOUA OLIGOSTACHYA (Nutt.) Torr.

Common on the tops of all the taller mounds. (Watson No. 798.)

BOUTELOUA CURTIPENDULA (Michx.) Torr.

Common on all the mounds in bare ground. (Watson No. 800.)

BOUTELOUA HIRSUTA Lag.

Abundant all over the mounds, and constitutes the principal forage for grazing. (Watson No. 799.)

ACC NO. 2988